

FINAL REPORT

SPACE SHUTTLE/ FOOD SYSTEM STUDY

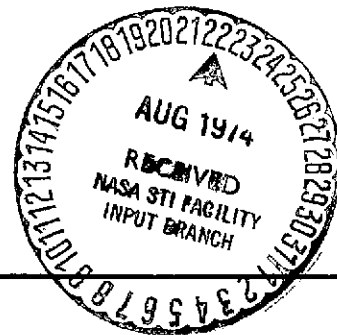
VOLUME II

APPENDIX E

ALTERNATE FLIGHT SYSTEMS ANALYSIS

prepared for
NATIONAL AERONAUTICS and SPACE ADMINISTRATION
Johnson Spacecraft Center
Houston, Texas 77058

Contract NAS9-13138



Prepared by



THE PILLSBURY CO.

(NASA-CR-134377) SPACE SHUTTLE/FOOD
SYSTEM STUDY. VOLUME 2, APPENDIX E:
ALTERNATE FLIGHT SYSTEMS ANALYSIS
(Pillsbury Mills, Inc.) 94 p HC \$7.75

N74-33585

Unclas
46374

CSC 06H 63/05

APPENDIX E
ALTERNATE FLIGHT SYSTEMS ANALYSES

ALTERNATE FLIGHT SYSTEMS ANALYSIS

Table of Contents

<u>Section</u>	<u>Title</u>	<u>Page</u>
1.0	Introduction	1
2.0	Discussion	1
2.1	Method of Analyses	1
2.2	Validity	12
2.3	Contingency and Growth	13
3.0	Detailed Analysis	14
3.1	System I	14
3.1.1	Food and Primary Packaging	14
3.1.2	Equipment	16
3.1.3	Installation - Weights and Volume Penalties	21
3.2	System II	22
3.2.1	Food Types and Quantity	22
3.2.2	Equipment	26
3.2.3	Installation - Weight and Volume Penalties for Equipment Installation	33
3.3	System III	36
3.3.1	Food Types and Quantities	36
3.3.2	Equipment	45
3.3.3	Installation	52
3.4	System IV	58
3.4.1	Food Types and Quantities	58
3.4.2	Stowage Equipment	64
3.4.3	Installation	69
3.5	System V	71
3.5.1	Food Types and Quantities	71
3.5.2	Stowage Equipment	79
3.5.3	Installation	86

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Beverage Pack Arrangement System I	18
2	Beverage Package - Effective Stacking Dimensions	23
3	Ready-to-Eat Package (RTE)	24
4	System II - Reduced Configuration	27
5	Overage	28
6	System II - Packaging by Category	28
7	Beverage Package - Effective Stacking Dimensions	38
8	Ready-to-Eat Package (RTE)	39
9	Beverages and RTE - one day overwrap	41
10	Crew Meal Packaging Plan - BEV. and RTE One Day Supply	42
11	Rehydratables - One Day Overwrap	43
12	Crew Meal Packaging Plan - Rehydratables (One Day Supply)	44
13	Tray assembly	50
14	Bev/RTE and Rehydratable Arrangements	62
15	Refrigerated Food Package Arrangements	63
16	Bev/RTE Arrangement	76
17	Rehydratable Wet Pack Arrangements	77
18	Refrigerated and Frozen Food Package Arrangements	78

LIST OF ILLUSTRATIONS

<u>Table</u>	<u>Title</u>	<u>Page</u>
1	Systems Summary	2
2	Provide for Stowage	3
3	Provide for Preparation	5
4	Provide for Serving	7
5	Provide for Consumption	8
6	Provide for Clean-Up	10
7	System I Summary	15
8	System I Summary	19
9	System II Summary	35
10	System III Summary	37
11	System IV Summary	59
12	System V Summary	72

1.0 INTRODUCTION

The analyses contained within this appendix to Volume II of the Shuttle Food System Final Report are the bases for establishing the weight and volume penalties of five alternate flight feeding systems. The feeding systems were initially established by the five alternate food mixes chosen for study. These alternate food mixes, representing the most austere to the most luxurious, each establish a set of requirements for equipment and its installation. Summary weight and volume data for all five systems in terms of food and packaging, support equipment and galley installation penalties are presented in Table 1.

2.0 DISCUSSION

2.1 Method of Analysis

A systems analysis to describe the functional requirements of stowage, preparation, serving, consumption, and cleanup was applied to each of the five selected food mixes. This led to a definition of performance requirements for each food mix and subsequently a definition of equipment to meet those performance requirements was developed. That analysis is summarized in Tables 2 through 6. In each table, requirements are designated by square bullets and systems are designated by Roman numerals I through V.

TABLE 1

SYSTEMS SUMMARY

SUMMARY TABLE

	I LB FT ³	II LB FT ³	III LB FT ³	IV LB FT ³	V LB FT ³
FOOD & PRIMARY PACKAGING	86.7 2.68	103. 2.35	140. 7.24	172. 7.68	217. 7.76
EQUIPMENT TOTAL	18.1 3.21	27.0 2.94	88.9 11.7	120. 12.8	224. 14.6
GALLEY INSTALLATION	16.6 4.61	14.6 4.0	47.6 12.9	61.8 17.2	65.1 18.1
TOTAL GALLEY (LESS FOOD)	34.7 7.8	41.6 7.0	136.5 24.6	182. 30.0	289. 32.7

TABLE 2

PROVIDE FOR STOWAGE

	I	II	III	IV	V
■ FOOD TYPE & QUANTITY	• BEVERAGE 266	• BEVERAGE 350 RTE 266	• BEVERAGE 357 • RTE 175 • RHYD 308	• BEVERAGE 357 • RTE 175 • RHYD 266 REFRIG 48	• BEVERAGE 350 • RTE 175 • RHYD 175 • REFRIG 48 • WET PACK 49 • FROZEN 48
■ LOCATION	• ON-BOARD STOWAGE	• ON-BOARD STOWAGE	• GALLEY STOWAGE	• GALLEY STOWAGE	• GALLEY STOWAGE
■ CONFIGURATION MANAGEMENT	• NO ON-BOARD MENU CHOICE	• NO ON-BOARD MENU CHOICE	• TRADE-OFF ON-BOARD vs ON-GROUND MENU CHOICE	• ONE MEAL ON-BOARD MENU CHOICE	• FULL ON-BOARD MENU CHOICE
■ ENVIRONMENTAL REQUIREMENTS	• AMBIENT	• AMBIENT	• AMBIENT	• AMBIENT • PROVIDE 40° - 45°F	• AMBIENT • PROVIDE 40° - 45°F 0° - 5°F

TABLE 2 Cont'd

PROVIDE FOR STOWAGE (CONT'D)

	I	II	III	IV	V
■ STOWAGE EQUIPMENT	• BEVERAGE LINER • LOCKER	• BEVERAGE LINER • LOCKER • RTE LINER • LOCKER	• BEV/RTE LINER • LOCKER • RHYD. LINER • LOCKER	• BEV/RTE LINER • LOCKER • RHYD. LINER • LOCKER • REFRIG. LINER • REFRIGERATOR	• BEV/RTE LINER • LOCKER • RHYD/WET PACK LINER • LOCKER • REFRIG. LINER • REFRIGERATOR • FREEZER LINER • FREEZER

TABLE 3

PROVIDE FOR PREPARATION

	I	II	III	IV	V
■ INVOLVEMENT	• INDIVIDUAL	• INDIVIDUAL	• ONE MAN	• ONE MAN	• ONE MAN
■ TASKS	• REHYDRATE BEVERAGES 6/MAN DAY	• REHYDRATE BEVERAGES 6/MAN DAY	• REHYDRATE BEVERAGES 2/MAN MEAL	• REHYDRATE BEVERAGES 2/MAN MEAL	• REHYDRATE BEVERAGES 2/MAN MEAL
			• REHYDRATE ENTREES AND SIDE DISHES 1-3/MAN MEAL	• REHYDRATE ENTREES AND SIDE DISHES 1-3/MAN MEAL	• REHYDRATE ENTREES AND SIDE DISHES 1-3/MAN MEAL
			• ASSEMBLE HOT ENTREES FOR TEMP.RET.	• ASSEMBLE HOT ENTREES FOR TEMP.RET.	• ASSEMBLE HOT ENTREES FOR TEMP.RET.
					• ASSEMBLE FROZEN & WET PACK ENTREES FOR HEATING

TABLE 3 Cont'd

PROVIDE FOR PREPARATION (CONT'D)

	I	II	III	IV	V
■ TEMPERATURE REQUIREMENTS	• BEVERAGE AMBIENT	• BEVERAGE AMBIENT	• BEVERAGE- 45°F • BEVERAGE-155°F • REHYD -149°F	• BEVERAGE- 45°F • BEVERAGE-155°F • REHYD -149°F	• BEVERAGE- 45°F • BEVERAGE-155°F • REHYD -149°F • WET PK -149°F • FROZEN -149°F
■ PREPARATION EQUIPMENT	• WATER SYSTEM AMBIENT W=60 LB/HR	• WATER SYSTEM AMBIENT W=60 LB/HR	• WATER SYSTEMS 45°F/160°F W ₁ =60 LB/HR W ₂ =60 LB/HR	• WATER SYSTEMS 45°F/160°F W ₁ =60 LB/HR W ₂ =60 LB/HR	• WATER SYSTEMS 45°F/160°F W ₁ =60 LB/HR W ₂ =60 LB/HR
			• HOT INSERT TRAY • WORK SURFACES • SEMI-ACTIVE HOLDING OVEN • HANDLING EQUIPMENT(HOT) • UTENSILS	• HOT INSERT TRAY • WORK SURFACES • SEMI-ACTIVE HOLDING OVEN • HANDLING EQUIPMENT(HOT) • UTENSILS	• HOT INSERT TRAY • WORK SURFACES • HOT AIR HOLDING & HEATING OVEN • HANDLING EQUIPMENT(HOT) • UTENSILS

TABLE 4

PROVIDE FOR SERVING

	I	II	III	IV	V
■ INVOLVEMENT	• SELF	• SELF	• ONE MAN	• ONE MAN	• ONE MAN
■ MAN MEAL COMPOSITION	• 1-3 BEV	• 1-3 BEV	• 2 BEVERAGE • 1 RTE • 1-3 REHYDRATED RTE	• 2 BEVERAGE • 1 RTE • 1-3 REHYDRATED • 0-1 REFRIG.	• 2 BEVERAGE • 1 RTE • 1-3 REHYDRATED • 0-1 REFRIG. • 0-1 WET PACK • 0-1 FROZEN
■ TEMPERATURE	• AMB	• AMB	• 155°F BEVERAGE • 149°F REHYDRATED	• 155°F BEVERAGE • 149°F REHYDRATED • 45°F REFRIG.	• 155°F BEVERAGE • 149°F REHYDRATED • 45°F REFRIG.
■ SERVING EQUIPMENT	• NONE	• NONE	• ASSEMBLY TRAY • HOT INSERT • HOT GLOVE	• ASSEMBLY TRAY • HOT INSERT • HOT GLOVE	• ASSEMBLY TRAY • HOT INSERT • HOT GLOVE

TABLE 5

PROVIDE FOR CONSUMPTION

		I	II	III	IV	V
■ DINING TIME		NA	NA	20 MINUTES	20 MINUTES	20 MINUTES
• BREAKFAST	BEVERAGE	1 A	2 A	2 H/C	2 H/C	2 H/C
	RTE		1	1	1	1
	REHYDRATABLE			1 H	1 H	1 H
• LUNCH	BEVERAGE	2 A	2A	2 H/C	2 H/C	2 H/C
	RTE		2	1	1	1
	REHYDRATABLE			3 H	3 H	3 H
• DINNER	BEVERAGE	2 A	2 A	2 H/C	2 H/C	2 H/C
	RTE		2	1	1	1
	REHYDRATABLE			3 H	2 H	0
	REFRIGERATED				1 C	1 C
	WET PACK					1 H
	FROZEN					1 H
• SNACK	BEVERAGE	1 A	2 A	2 H/C	2 H/C	2 H/C
	RTE		1	1	1	1

A - AMBIENT

H - HOT

C - COLD

TABLE 5 Cont'd

PREPARE FOR CONSUMPTION (CONT'D)

	I	II	III	IV	V
• DINING EQUIPMENT	• SCISSOR	• SCISSOR	• SCISSOR • FORK • SPOON	• SCISSOR • FORK • SPOON	• SCISSOR • FORK • SPOON • KNIFE

NOTE: ALL UTENSILS ARE FULL SIZE

TABLE 6

PROVIDE FOR CLEAN-UP

	I	II	III	IV	V
TRASH TYPE	<ul style="list-style-type: none"> • WATER SPILLS DURING REHYDRATION BEVERAGE PKG 	<ul style="list-style-type: none"> • WATER SPILLS DURING REHYDRATION BEVERAGE PKG • DRY PARTICULATE RTE FOOD SPILL 	<ul style="list-style-type: none"> • WATER SPILLS DURING REHYDRATION BEVERAGE PKG REHYD PKG • DRY PARTICULATE RTE FOOD SPILL • WET FOOD SPILLS REHYD FOOD 	<ul style="list-style-type: none"> • WATER SPILLS DURING REHYDRATION BEVERAGE PKG REHYD PKG • DRY PARTICULATE RTE FOOD SPILL • WET FOOD SPILLS REHYD FOOD REFRIG FOOD 	<ul style="list-style-type: none"> • WATER SPILLS DURING REHYDRATION BEVERAGE PKG REHYD PKG • DRY PARTICULATE RTE FOOD SPILL • WET FOOD SPILLS REHYD FOOD REFRIG FOOD WET PACK FOOD RECONSTITUTED FROZEN FOOD
TRASH QUANTITY	<ul style="list-style-type: none"> • BEVERAGE PKG 266 *(1/1) 	<ul style="list-style-type: none"> • BEVERAGE PKG 350 (1/1) • RTE PKG 175(.25/1) 	<ul style="list-style-type: none"> • BEVERAGE PKG 357 (1/1) • RTE PKG 175(.25/1) • REHYD PKG 308 (1/1) 	<ul style="list-style-type: none"> • BEV. BELLOWS PKG 357(1.5/1) • RTE PKG 175(.25/1) • REHYD PKG 266 (1/1) • REFRIG PKG 48 (1/1) 	<ul style="list-style-type: none"> • BEV. BELLOWS PKG 357(1.5/1) • RTE PKG 175(.25/1) • REHYD PKG 175(1/1) • REFRIG PKG 48(1/1) • WET PACK PKG 49 (1/1) • FROZEN FOOD PKG 48 (1/1)

* TRASH VOLUME/PACKAGE VOLUME RATIO

TABLE 6 Cont'd

PROVIDE FOR CLEAN-UP (CONT'D)

	I	II	III	IV	V
CLEAN-UP EQUIPMENT	<ul style="list-style-type: none"> • GALLEY WIPES • TRASH COLLEC- TION BAG • TRASH STOWAGE LINER 1/1 OF FOOD LINER 	<ul style="list-style-type: none"> • GALLEY WIPES • TRASH COLLEC- TION BAG • TRASH STOWAGE LINER 1/1 OF FOOD LINER 	<ul style="list-style-type: none"> • GALLEY WIPES • UTENSIL WIPES • BEV/RTE MEAL BAG • RHYD MEAL BAG • TRASH STOWAGE LINER 1/7 OF FOOD LINERS 	<ul style="list-style-type: none"> • GALLEY WIPES • UTENSIL WIPES • BEV/RTE MEAL BAG • RHYD MEAL BAG • REF TRASH BAG • TRASH STOWAGE LINER 1/7 OF DRY FOOD LINERS 1/1 OF REF LINER 	<ul style="list-style-type: none"> • GALLEY WIPES • UTENSIL WIPES • BEV/RTE MEAL BAG • RHYD/WET PK BAG • REF/FREEZER TRASH BAG • TRASH STOWAGE LINER 1/7 OF BEV/RTE LINERS LINER 1/7 OF REHYD/WET PK 1/1 OF REF LINER 1/1 OF FREEZER LINER
	<ul style="list-style-type: none"> • PERSONAL WIPES 	<ul style="list-style-type: none"> • PERSONAL WIPES 	<ul style="list-style-type: none"> • PERSONAL WIPES • DISINFECTANT PACKET 	<ul style="list-style-type: none"> • PERSONAL WIPES • DISINFECTANT PACKET 	<ul style="list-style-type: none"> • PERSONAL WIPES • DISINFECTANT PACKET

Detail Approach

Where an equipment class, i.e., refrigerator, was identified through the systems analysis process it then became necessary to establish which type, i.e., thermo-electric, vapor cycle, expendable ammonia, was most applicable to the shuttle orbiter mission requirements and constraints. For selection of major equipment types, including refrigerators, freezers, ovens and ambient stowage equipment data had been developed for this study by the following studies appended to Volume II of the Shuttle Orbiter Food System Final Report:

ACTIVE HEATING SYSTEMS SCREENING	- Appendix A
RECONSTITUTED FOOD HEATING TECHNIQUES ANALYSIS	- Appendix B
FOOD COOLING TECHNIQUES	- Appendix C
PACKAGE AND STOWAGE ALTERNATE CONCEPTS ANALYSIS	- Appendix D

2.2 Validity

The analyses presented in this volume are of varying depth and scope. The greatest effort was applied to the System III food mix from which the galley mockup was described and developed. Where there were recognized similarities or sameness between a component for one system and another, a new analysis was not performed, but rather the data from the original analysis was utilized or scaled up or down as the case required. This technique was used primarily for weights of components where additional detailed analyses were beyond the scope of the program. Where assumptions and estimates are made, they are so noted.

2.3 Contingency and Growth

Since this study is concept and soft mockup oriented and recognizes that interface requirements and guidelines will change as actual shuttle subsystems are developed, the summary weight and volume values presented for each system are 130% of values calculated in the analyses to allow for contingency and growth.

3.0 Detailed Analysis

3.1 System I (See Table 7)

3.1.1 Food and Primary Packaging

Food Types and Quantity

- Beverage

Food Weight 3.51 oz. ea.

Pkg. Weight .50 oz. ea. (valve inc.)
4.01 oz. ea.

Quantity 6 per man day x 6 men x 7 days = 252

Overage (5%)(252) = 14 carry → 14

Total Bev. Packs per mission 266

Food and Primary Packaging Weight Per Mission

- Beverage

Food Weight 3.51 oz. x 266 = 935 oz. = 58.4 lb.

Pkg. Weight .50 oz. x 266 = 133 oz. = 8.3 lb.

Total Food Pkg. 66.7 lb.

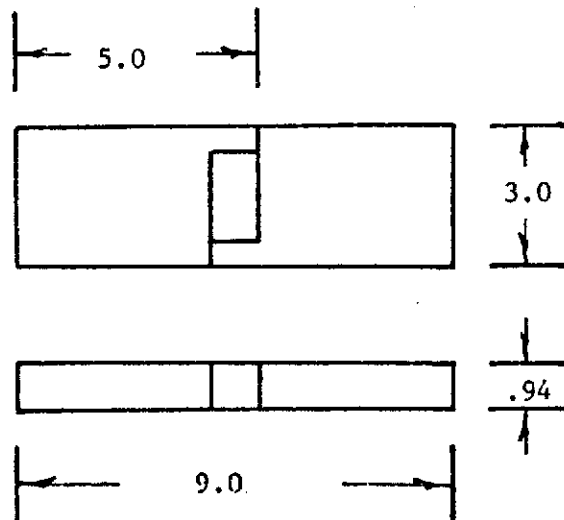
Stacked Dimensions (Minimum Volume Analysis)

- Beverage Package 5 in x 3 in x 0.94 in overall

$$V_B = 266 (5 \times 3 \times 0.94) = 3750 \text{ in}^3 = 2.17 \text{ Ft}^3$$

Arrangement

- Beverage Pack - It is found that the effective length of 2 packages stacked as shown below can be reduced from 10 in. to 9.0 in.



3.1.1.1 Cont'd

Seven separate bulk overwraps of 38 Bev. packs (1 Crew Day quantity) are stacked in one liner. See Figure I-1.

New Minimum Volume

$$V_{B_1} = \frac{266}{2} (9 \times 3 \times .94) = 3376 \text{ in}^3$$

TABLE 7
SYSTEMS SUMMARY

System 1		
Food and Primary Package	LB*	FT ³ *
	86.7	2.63
Logistics Liner	12.8	2.81
Water System	1.00	0.13
Wipes and Dispensers	4.29	0.27
Equipment Totals	18.1	3.21
Food Lockers	5.85	1.62
Equipment Installation	0.91	0.25
Miscellaneous Hardware	0.26	0.06
Trash (1/1 of Food and Pkg. Volume)	9.62	2.68
Installation Totals	16.6	4.61
Total System (Less Food)	34.7	7.82

* Weight and Volumes are 1.3 x Calculated to allow for growth and contingency

3.13.1.2 Equipment

• Dimensional Analysis Logistics Liner See Fig. I-1

COMPONENTS	W(in)	D(in)	H(in)
Bev. Pack(38 Bev Pkg)	9.0	17.86	3.0
.006" Overwrap	.012	.012	.012
.010" TFE Spacer			.010
Internal Volume Utilized V_U			In^3
Bev. Pack x 7(9.012 x 17.872 x 3.012) =			3390
.010 TFE Spacer x 6(9.012 x 17.872 x .010) =			$\frac{9.65}{3399.64}$
Pkg. Arrang. Loss x 7 (1.0 x 2.0 x 17.86) =			$\frac{250.0}{-}$
		V_U	3149.65

Max. Overall Dimensional Vol.Stacked Food V_S

$$W = 9.012 \quad D = 17.862 \quad H = 22.144 \quad V_S = 3550 \text{ in}^3$$

$$\bullet \text{ Arrangement Efficiency } \frac{V_U}{V_S} \times 100 = 89\%$$

$$\bullet \text{ Volume Efficiency } \frac{V_{B1}}{V_S} \times 100 \frac{3376 \text{ in}^3}{3550 \text{ in}^3} = 95\%$$

Stowage Equipment

	<u>Mission Logistics Liner</u>	<u>W(in)</u>	<u>D(in)</u>	<u>H(in)</u>	<u>In^3</u>
a	Food Day Layer	9.00	17.86	3.00	482.22
b	Overwrapped Layer	9.012	17.872	3.012	485.12
c	Seven Layer Stack	9.012	17.872	22.144	3566.
d	Clearance .062"/Surface	.124	.124	.124	
e	Inside Dimension	9.136	17.986	22.268	3659.
f	Liner Thickness .060"/Surf.	.120	.120	.120	
g	Outside Dimension	9.256	18.106	22.388	3752.
H	Spacer .010" Thickness	9.012	17.872	0.010	1.61

3.1.2 Cont'd

• Materials

Liner - Epox Moulding Compound Glass Fiber Fill .068 lb/in³

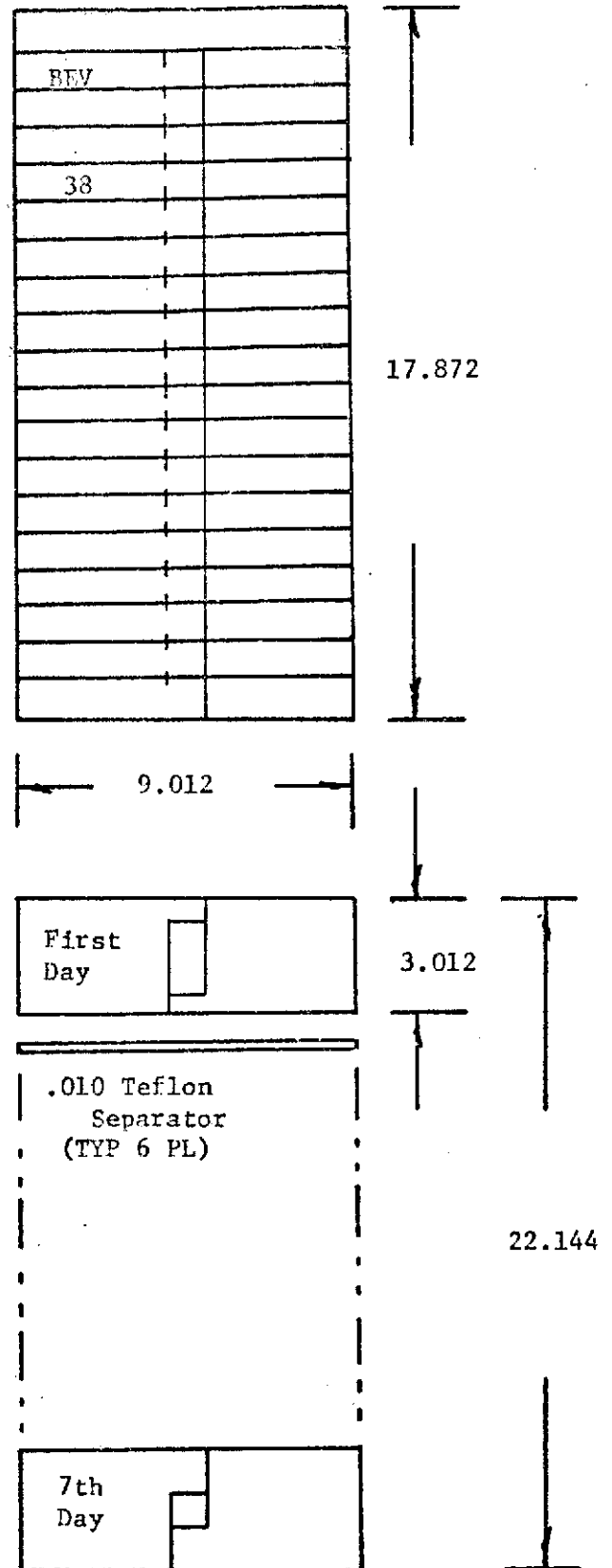
Spacers - TFE .078 lb/in³

Overwrap - Polyeth .035 lb/in³

• Material Weights

	In ³	x	EA.	x	ρ	= lb.
Overwraps(b-a) (485.12- 482.22)	2.90		7		.035	0.71
Spacers h	1.61		6		.078	0.75
Liner (g-e) (3752-3659) =93.			1		.068	6.32

SYSTEM I



The above consists of 266 Beverage packs. (36 + 2 overage per day)

FIGURE I Bev. Pack Arrangement

SYSTEM I

FOOD AND PRIMARY PACKAGE	LB	FT ³
	86.7	2.68
LOGISTICS LINER	12.8	2.81
WATER SYSTEM	1.00	0.13
WIPES AND DISPENSERS	4.29	0.27
EQUIPMENT TOTALS	18.1	3.21
FOOD LOCKERS	5.85	1.62
EQUIPMENT INSTALLATION	0.91	0.25
MISCELLANEOUS HARDWARE	0.26	0.06
TRASH (1/1 OF FOOD AND PKG VOLUME)	9.62	2.68
INSTALLATION TOTALS	16.6	4.61
TOTAL SYSTEM (LESS FOOD)	34.7	7.82

* Weight and Volumes are 1.3 x calculated to allow for growth and contingency.

TABLE 8

3.1.2 Cont'd

Stowage Summary		lb.	In ³	Ft ³
Food Bev } Pkg. } Bev. }	Food &	58.4		-
	Pkg.			
	8.3	-	-	
Overwraps } Spacers } Liner }		3.68	$\rho_v = 20.3$	-
	Liner	.76	$\rho_v = 11.3$	-
		5.44	3740	2.16
TOTAL		76.58	1b.3740 In ³	2.16 Ft ³

- Water System 0.7 lb. - 0.10 Ft³

Ambient water rehydration system requires hand operated and held water gun on flexible hose interfacing with galley for mounting and coupling.

Gun	9 in x 4 in x 1 in = 36 in ³	Lb.	Ft ³
		0.5 lb(est.)	
Line & Interface(Est.)	$\frac{135 \text{ in}^3}{171}$	0.2 " "	0.10
		0.7 lb.	

- Wipes and Dispensers 3.28 lb. - .21 Ft³

- Wipes - 168 ea. x .013 lb. ea. = 2.18 lb.

Personal wipes are paper towelettes 5.5 x 8.0 in. in size, impregnated with solution of Benzalkonium Chloride, Chlorothymol, Propylene Glycol and Alcohol 20%. The wipe is folded and sealed in foil envelope 2.25 in. x 3.0 in x .125 in and weight approximately .013 Lbs. -

Use 4 per man day.

- Dispenser - 1.1 lb. .21 Ft³

Dispenser is a box-type enclosure of aluminum construction providing for internal retention and dispensing of wipe packets one at a time by means of negator spring plate pressure. The unit must be flush mounted on a smooth surface. Wipe packets are stowed 2 x 84 in the dispenser. Sized 5.0 x 5.6 x 11.6 with estimated weight of 1.1 lbs.

3.1.3 Installation - Weights and Volume Penalties

Equipment Installation

Food Locker	4.5 lb.	1.25 Ft ³	
	In x In x In.		In ³
Liner Dimension	9.256 x 18.106 x 22.388		3752
Clearance .05 in/ Surface	.10	.10	.10
Structure 1.0 in/ Surface	2.0	2.0	2.0
Access Face		1.0	
Overall Dimension	11.356 x 21.206 x 24.488		5897
Stowage Volume	5897 in ³		
Liner Volume	<u>3752 in³</u>		
Stowage Density Vol.	2145 in ³	→	1.25 Ft ³
Frame Structure Weight Penalty	3.6 lb/Ft ³		
Food Locker Weight	1.25 Ft ³ x 3.6 lb/Ft ³		= 4.5 lb.
And Volume Penalty			1.25 Ft ³
Equipment Installation			
Factored as 1/2 of 1/5 = 1/10 of total equipment installation weight of System III			
See Sec. 3.3 - includes dispenser	.50 lb.	.13Ft ³	
Penalty for mounting water gun and flexible line (Estimate)	.20 lb.	.05Ft ³	
Miscellaneous hardware factored as 1/2 of System III Sec. 3.3	.20 lb.	.05Ft ³	
Trash Max. 1/1 of Food and Package			
Volume - Wt. = 3.6 lb/Ft ³ x Vol.	7.40 lb.	2.06Ft ³	

3.2 System II

3.2.1 Food Types and Quantity

- Beverage

Food Weight 1.23 oz. ea.

Pkg. Weight 0.50 oz. ea. with valve
1.73 oz. ea.

Quantity 8 per man per day x 6 men x 7 days = 336 per mission

Overage (5%)(336) = 16.8 carry $\frac{14}{266}$ Total RTE

- RTE (Ready-to-Eat) Bar

Food Weight 2.28 oz. ea.

Pkg. Weight .25 oz. ea.
2.53 oz. ea.

Quantity 6 per man per day x 6 men x 7 days = 252 per mission

Overage (5%)(252) = 12.6 carry $\frac{14}{266}$ Total RTE

Food and Primary Package Weight per Mission

- Beverage

Food Weight 1.23 oz. x 350 = 430.50 oz. = 26.91 lbs.

Pkg. Weight 0.50 oz x 350 = 175.00 oz. = 10.94 lbs.

37.85 lbs. → 37.85 lb.

- RTE Bar

Food Weight 2.28 oz x 266 = 606.48 oz = 37.90 lbs.

Pkg. Weight 0.25 oz. x 266 = 66.50 oz. = 4.16 lbs.
42.06 lbs. → 42.06 lb.

Mission Food & Primary Pkg. Weight

79.91 lb.

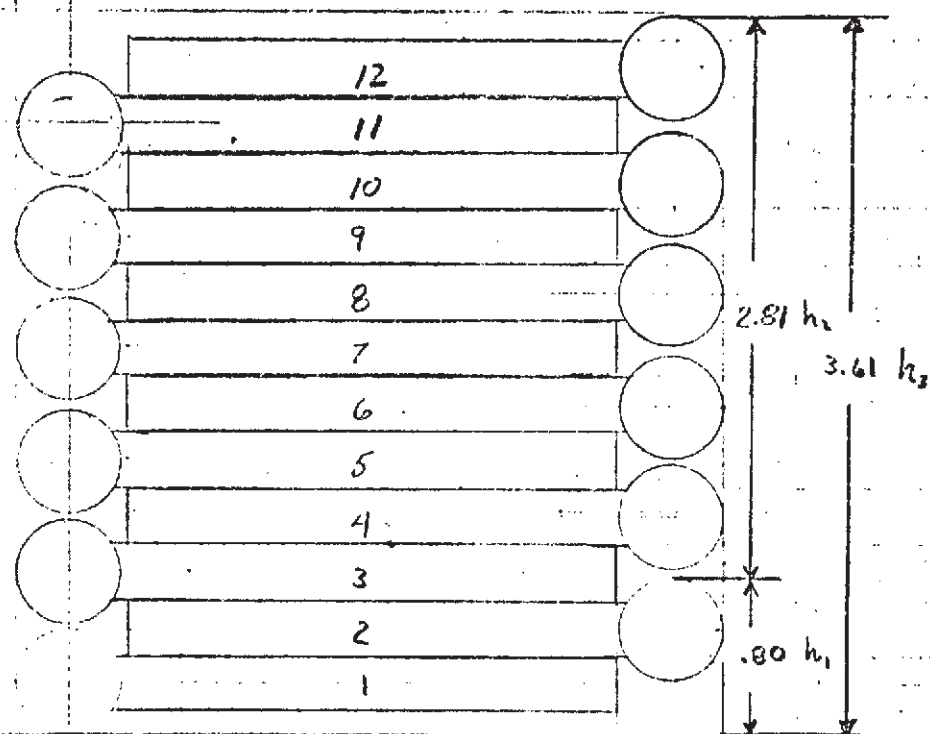
Dimensional Analysis - Minimum Volume Analysis

- Beverage Pack (See Fig. II-1)

Individual dimensions [3 in x 5 in x .28 in] effective

stacking dimension 3.5 x 5 x [(n-2).281 + .80]

$V_{Bev} = 3.5 \times 5 \times [(350)(.281) + .80] = 1735 \text{ in}^3 \rightarrow 1.004 \text{ Ft}^3$



h_1 = height of 1st two pkgs. = CONSTANT .80 IN

h_2 = height of $(n-2)$ packages = $2.81 / 10$ PKGS

$h_3 = h_1 + h_2$

$h_{1/2} = [.80 + .281(n-2)]$

FIGURE 2

BEVERAGE PKG. EFFECTIVE STACKING DIMENSION

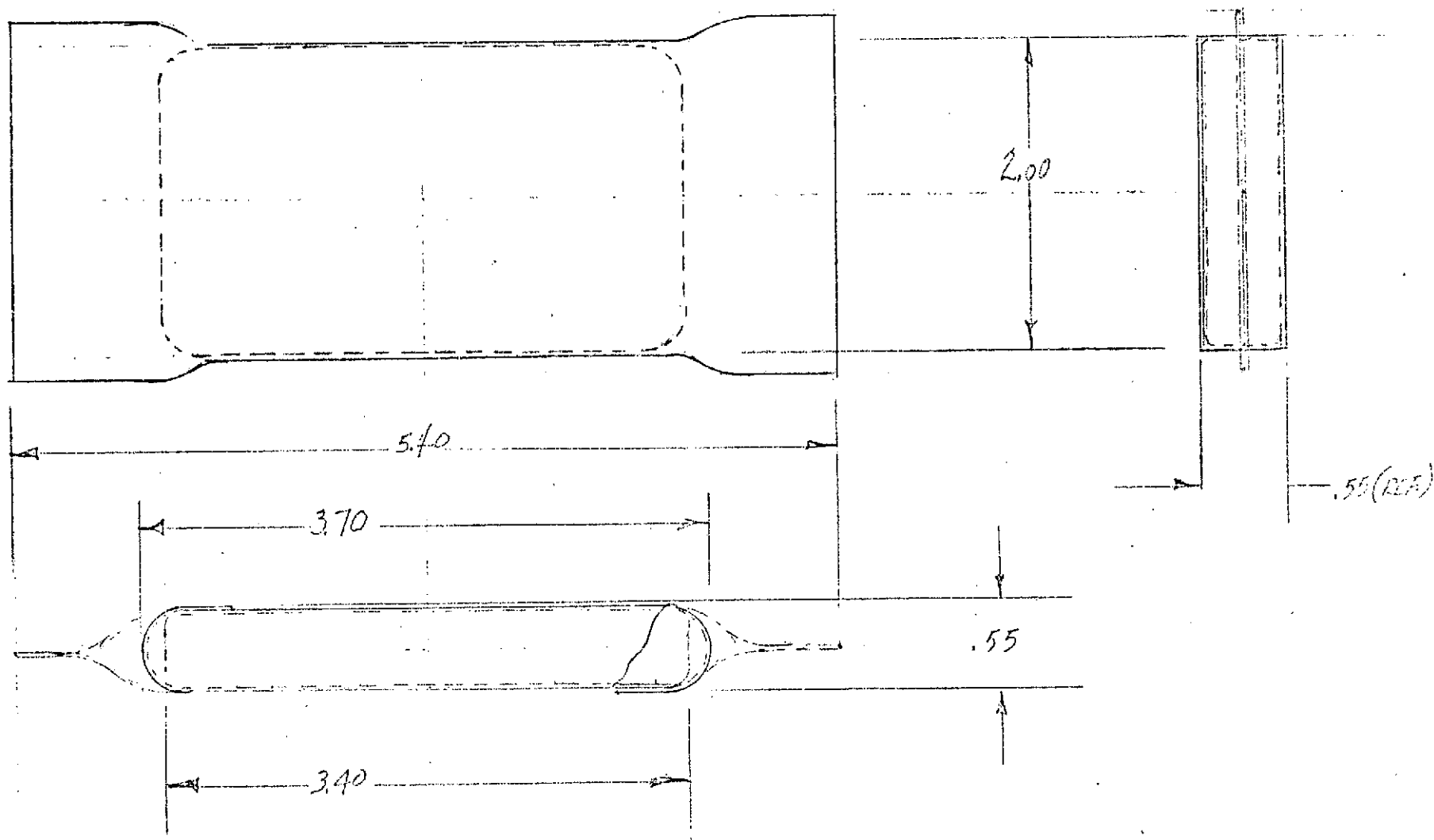


FIGURE 3

READY TO EAT PKG. (R.T.E.)

3.2.1 Cont'd

- RTE (See Fig. II-2)

Pkg. end flaps folded back over one end and back under the other.

Individual packaged ready for stacking dimension-

[2.0 in x 3.7 in. x .55 in]

Total Pkg. $266[2.0 \times 3.7 \times .55] = 1082 \text{ in}^3 = .626 \text{ Ft}^3$

- Total minimum volume stacked food and primary packaging

350 Bev. Packs	1735 in^3	V_B	1.004 Ft^3
266 RTE Packs	$\frac{1082 \text{ in}^3}{2817 \text{ in}^3}$	V_{RTE}	$\frac{.626 \text{ Ft}^3}{1.630 \text{ Ft}^3}$

Arrangement

- Two Arrangement Cases Are Analyzed

Case 1 Arrangement of food packs is made into discrete crew breakfast, lunch, dinner, and beverage/snack overwraps. This results in 21 overwrapped meal packs and 7 overwrapped beverage snack units per mission. The overage of 14 beverage and 14 RTE packages is overwrapped as one unit and stowed separate from the meal pack overwraps. See Figure II-3 and II-3A.

Case 2 Separate bulk overwraps are provided for crew day quantities of beverage packs and RTE bars. The required overage quantities are included in the daily bulk overwraps. There are 7 beverage overwraps of 50 packages each, and there are 7 RTE overwraps of 38 packages each. See Figure II-4.

3.2.2 Equipment

• Dimensional Analysis

Case 1 Figure II-3 Single Logistics Liner

Components	W(in)	D(in)	H(in)	In ³
Breakfast Pack (12 RTE, 6 + 6 Bev)	5.000	12.350	2.000	123
.006" Overwrap	.012	.012	.012	
Lunch Pack (12 RTE, 6 + 6 Bev)	5.000	12.350	2.000	123
.006" Overwrap	.012	.012	.012	
Snack Pack (6 + 6 Bev)	3.500	10.000	2.000	70
.006" Overwrap	.012	.012	.012	
Dinner Pack (12 RTE, 6 + 6 Bev)	5.000	12.350	2.000	123
.006" Overwrap	.012	.012	.012	
.010" Teflon Spacer			.010	

<u>Internal Volume Utilized</u>		V _U	In ³
Breakfast Pack	x 7 (5.012 x 12.362 x 2.012)	=	872.6
Lunch Pack	x 7 (5.012 x 12.362 x 2.012)	=	872.6
Snack Pack	x 7 (3.512 x 10.012 x 2.012)	=	495.2
Dinner Pack	x 7 (5.012 x 12.362 x 2.012)	=	872.6
.010" Teflon Spacer	x 6 (5.012 x 12.362 x .010)	=	3.7
		V _U	= 3116.7

Maximum Overall Dimensional Vol. Stacked Food V_S

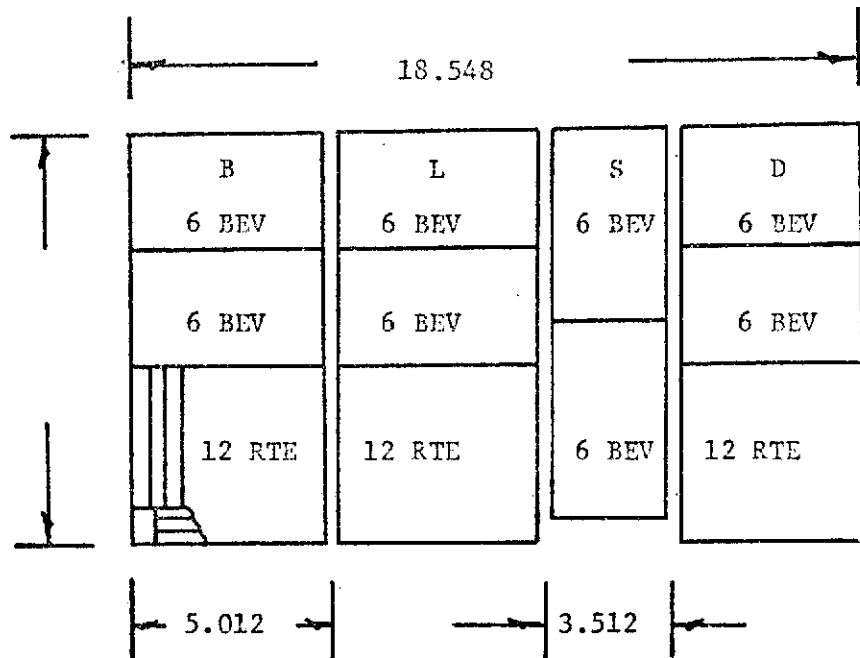
W = 18.548 in. D = 12.362 in. H = 14.144 In. V_S = $\frac{\text{In}^3}{3243.1}$

• Volume Efficiency $\frac{V_M}{V_S} \times 100 = \frac{2817}{3243} = 87\%$

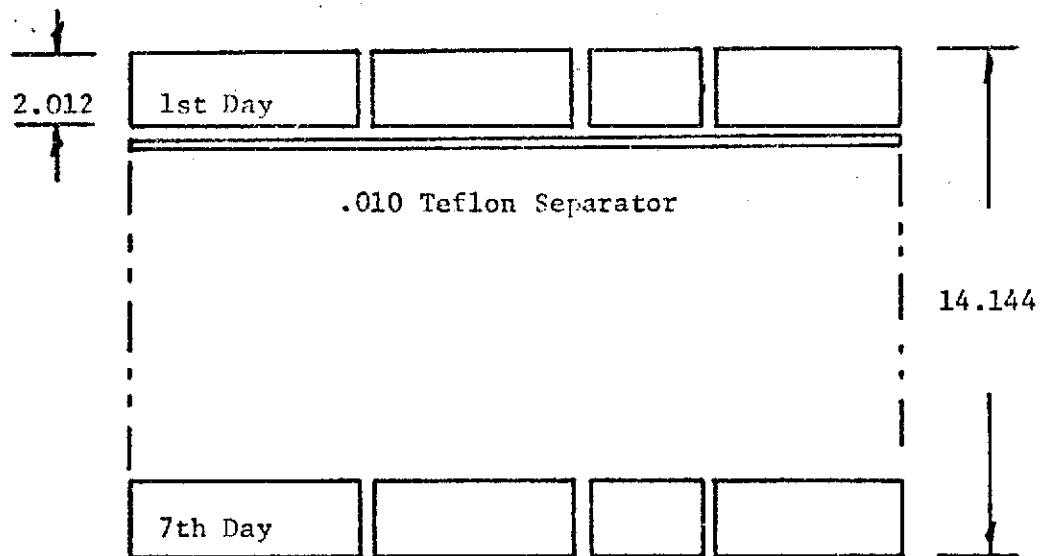
• Arrangement Efficiency $\frac{V_U}{V_S} \times 100 = 96\%$

Overage Figure II - 3A

	W(in)	D(in)	H(in)
Overage Pack (7 Bev, 7 RTE)	5.000	14.144	2.205
.006" Overwrap	.012	.012	.012
5.012 in 14.156 in 2.217 in = 157.2 in ³			



Plan View



Code: BEV - Beverage
 RTE - Ready-to-eat
 B - Breakfast
 L - Lunch
 D - Dinner
 S - Snack

FIGURE 4 SYSTEM II - REDUCED CONFIGURATION

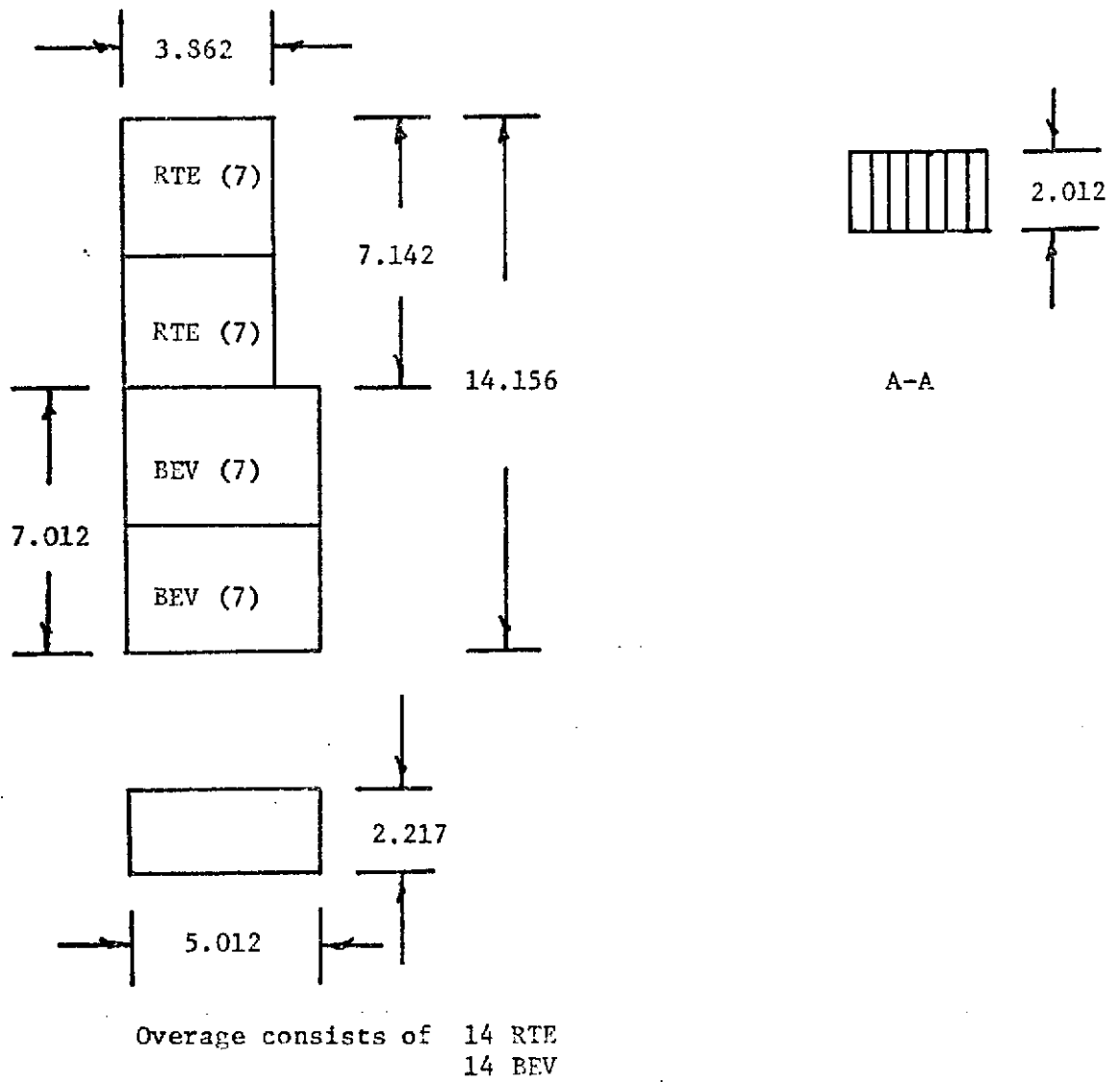


FIGURE 5 OVERAGE

3.2.2 Cont'd

Case 2 Figure II-4 Two Logistics Liners

Components	W(in)	D(in)	H(in)	In ³
Beverage Packs 50 ea.	10.000	17.500	1.640	285
.006" Overwrap	.012	.012	.012	
.010" Teflon Spacer			.010	

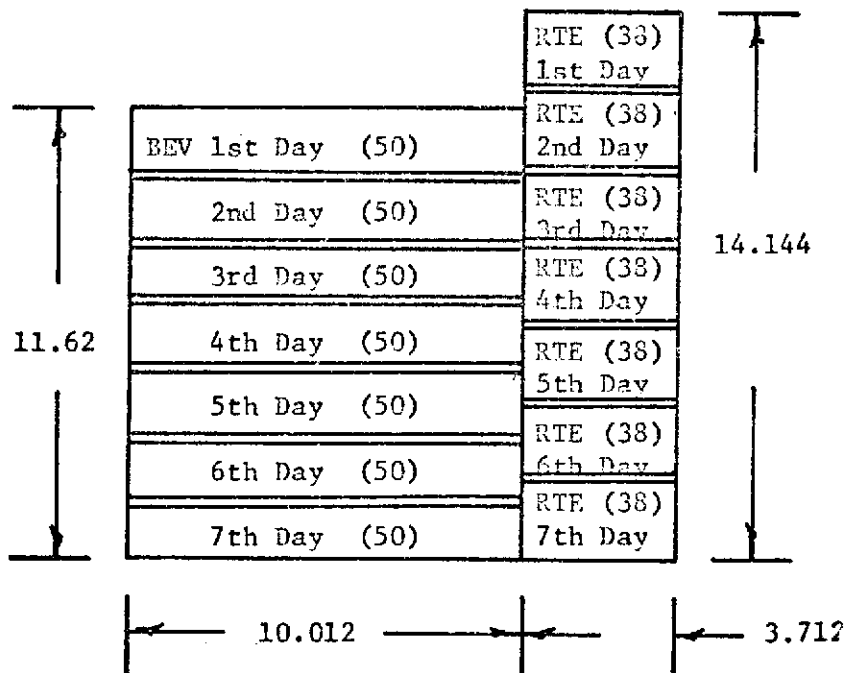
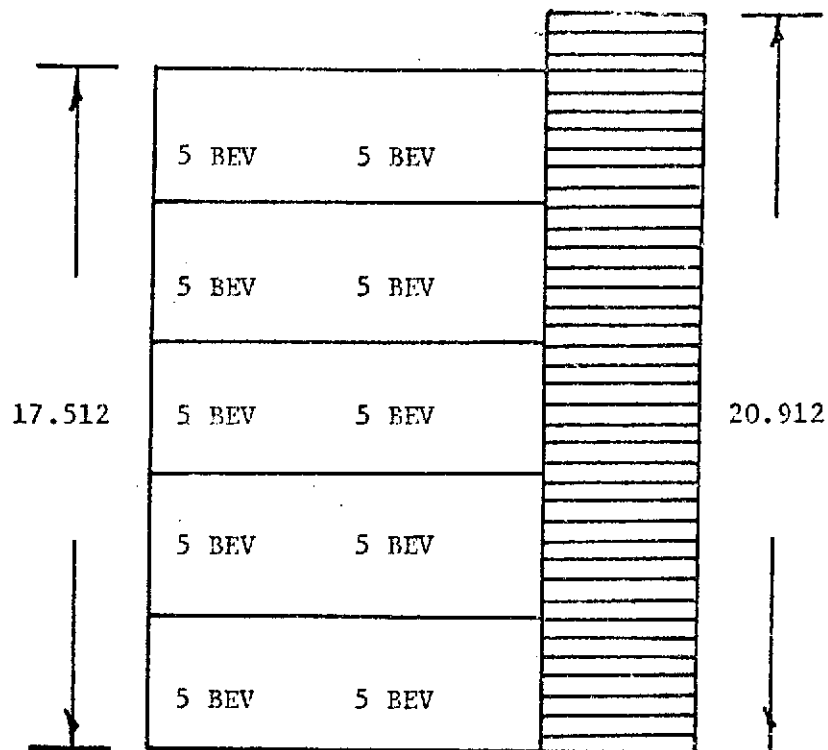
Internal Volume Utilized V_U

• Beverage Liner				In ³
Bev. Pack Overwrap	7 x (10.012 x 17.512 x 1.652)	=	2027	
.010" Teflon Spacer	6 x (10.012 x 17.512 x .010)	=	<u>10.5</u>	
		V_{UB}	=	2037.5
• RTE Liner				
RTE Pack Overwrap	7(3.712 x 20.912 x 2.012)	=	1093	
.010" Teflon Spacer	6(3.712 x 20.912 x .010)	=	<u>4.66</u>	
		V_{UR}	=	1097.7
	$V_T = V_{UB} + V_{UR}$	=	3135.2	

• Overage - included in daily packages.

Stowage Equipment

<u>Case 1 Bev/RTE Liner</u>	W(in)	D(in)	H(in)	In ³
a ₁ Food-day layer (48Bev- 36 RTE)	18.500	12.350	2.000	457.0
b ₁ Overwrapped Meal Packs	18.548	12.362	2.012	461.3
c ₁ Six TFE Spacers .010"Th.	18.548	12.362	.060	13.75
d ₁ Seven layer stack	18.548	12.362	14.144	3243.
e ₁ Clearance .062"/Surface	.124	.124	.124	
f ₁ Inside dimension	18.672	12.486	14.268	3326.
g ₁ Material .060" Th/Surf.	.120	.120	.120	
h ₁ Outside Dimension	18.792	12.606	14.388	3408



Includes 252 + 14 over=266 RTE
366 + 14 over=350 RTE

SYSTEM II
Packaging by Category

FIGURE 6

3.2.2 Cont'd

• Materials Densities

Liner - epox moulding compound glass fiber fill .068 lb/in³

Spacers - TFE .078 lb/in³

Overwrap - polyeth .035 lb/in³

• Weights

Overwraps $(b_1 - a_1) = (461.3 - 451.0) = 4.3$ In³ x Ea. x $\rho = \text{lb.}$
 $28 \times .035 = 4.21$

Spacers c_1 13.8 6/6 .078 = 1.08

Liner $(h_1 - f_1) = (3408 - 3326) = 82.$ 1 .068 = 5.58

$W_{T1} = 10.87$

Case 2 Separate Beverage and RTE Liners

• Beverage Liner	W(in)	D(in)	H(in)	In ³
A ₁ Food - Day Layer (50 Bev)	10.000	17.500	1.640	287.0
B ₁ Overwrapped Day Layer	10.012	17.512	1.652	289.6
C ₁ Six TFE Spacers .010"Th	10.012	17.512	.060	10.52
D ₁ Seven Layer Stack	10.012	17.512	11.624	2038.
E ₁ Clearance .062"/Surface	.124	.124	.124	
F ₁ Inside Dimension	10.136	17.636	11.748	2100.
G ₁ Material .060"Th/Surface	.120	.120	.120	
H ₁ Outside Dimension	10.256	17.756	11.868	2161.
• RTE Liner	W(in)	D(in)	H(in)	In ³
A ₂ Food-Day Layer (38 RTE)	3.700	20.900	2.000	154.6
B ₂ Overwrapped Day Layer	3.712	20.912	2.012	156.2
C ₂ Six TFE Spacers .010"Th	3.712	20.912	.060	4.66
D ₂ Seven Layer Stack	3.71 3.712	20.912	14.144	1098.
E ₂ Clearance .062"/Surface	.124	.124	.124	
F ₂ Inside Dimension	3.836	21.036	14.268	1151.
G ₂ Material .060" Th/Surf.	.120	.120	.120	
H ₂ Outside Dimension	3.956	21.156	14.388	1204.70

3.2.2 Cont'd

• Materials - Densities

Liner-Epoxy moulding compound Glass Fiber fill $\rho = .068 \text{ lb/in}^3$
 Spacers - TFE $\rho = .078 \text{ lb/in}^3$
 Overwrap - Polyeth $\rho = .035 \text{ lb/in}^3$

• Weights

Overwraps	in^3	x	EA	x	= lb
Bev (B_1-A_1)=(289.6-287.0)	2.6		7	.035	.637
RTE (B_2-A_2)=(156.2-154.6)	1.8		7	.035	<u>.441</u>
					1.08

Spacers

Bev C_1	10.52	10.52 x 6/6	.078	.820
RTE C_2	4.66	4.66 x 6/6	.078	<u>.363</u>
				1.18

Liners

Bev (H_1-F_1)	(2161-2100)	161.	1	.068	10.95
RTE (H_2-F_2)	(1204-1151)	53.	1	.068	<u>3.60</u>
					<u>14.55</u>
				W_{T2}	16.81

• Food & Primary Pkg. Volume

RTE Seven Layer Stack	1098 in^3
Bev Seven Layer Stack	$\frac{2038 \text{ in}^3}{3136 \text{ in}^3} = 1.81 \text{ Ft}^3$

Stowage Summary

Case 1	Quantity	Lb.	in^3	Ft^3
Food	336 Bev. 252 RTE	61.70		
Package	336 Bev. 252 RTE	14.44		
Overwraps	28	4.21		
Spacers	6	1.07		
Liner	1	<u>5.58</u>	<u>3408</u>	<u>1.972</u>
		87.00	3408	1.972

3.2.2 Cont'd

<u>Case 2</u>			Lb.	In ³	Ft ³
Food	336 Bev.	252 RTE	64.81		
Package	350 Bev.	266 RTE	15.10		
Overwraps	14		1.08		
Spacers	14		1.18		
Liners	1Bv, 1 RTE		16.81	3365	1.947
			98.98	3365	1.947

Case 2 Selected for System II

- Water System (Ambient) 0.7 lb. 0.10Ft³
Same as System I See Sec. 3.1.2
- Wipes and Dispenser 3.28 lb. 0.21 Ft³
Same as System I See Sec. 3.1.2

3.2.3 Installation - Weight & Volume Penalties for Equipment Installation

- Beverage Locker Dimensions

Liner Dimension (in)	10.256 in.	17.756 in.	11.863 in.	
Clearance 0.5/Surface	.1	.1	.1	
Structure 1.0/Surface	2.0	2.0	2.0	
Face Access 1.0	-	1.0	-	
Locker Dimension	12.356	20.856	13.968	3599 in ³ 2.08 Ft ³

- RTE Locker Dimensions

Liner Dimension	3.956 in.	21.156 in.	14.388 in.	
(As Above)	2.1	3.1	2.1	
	6.056	24.256	16.488	=2421 in ³
Total Food Stowage Volume				3.48 Ft ³

3.2.3 Cont'd

- Bev and RTE

Locker Weights	Density Vol. x 3.6 lb/Ft ³	
	Beverage	RTE
Stowage Volume	3599 in ³	2421 in ³
Liner Volume	2161 in ³	1204 in ³
Density Vol. (in ³)	1438 in ³	1217 in ³
Density Vol. (Ft ³)	.83 Ft ³	.70 Ft ³ = <u>1.53 Ft³</u>

Structure Weight

Wt. = Vol. x 3.6 lb/Ft ³	2.99 lb.	2.56 lb.	<u>5.55 lb.</u>
Food Lockers		5.55 lb.	1.53 Ft ³

- Equipment Installation

Same as for System I (3.1.3)	.50 lb.	.13 Ft ³
------------------------------	---------	---------------------

Water System Penalty Estimated

Same as System I (3.1.3)	.10 lb.	.06 Ft ³
--------------------------	---------	---------------------

Mount Gun and Flex Line

Miscellaneous Hardware Factored

As 1/2 of System III (Sec. 3.3)	.20 lb.	.05 Ft ³
---------------------------------	---------	---------------------

Trash Vol. Requirement 1.34 Ft³

Beverage Pkg. 1/1 of stowed vol.

1.18 x 1/1	1.18 Ft ³
------------	----------------------

RTE Pkg. 0.25/1 of stowed vol.

.64 x .25/1	0.16 Ft ³
-------------	----------------------

Trash Structure Penalty 4.83 lb.

Beverage	3.6#/Ft ³ x 1.18 Ft ³	4.25 lb.
----------	---	----------

RTE	3.6#/Ft ³ x 0.16 Ft ³	.58 lb.
-----	---	---------

SYSTEM II

FOOD AND PRIMARY PACKAGE	LB 103.	FT ³ 2.35
LOGISTICS LINERS (BEVERAGE LINER) (RTE LINER)	21.7	2.54
WATER SYSTEM (AMBIENT)	1.00	0.13
WIPES AND DISPENSERS	4.29	0.27
EQUIPMENT TOTALS	27.0	2.94
FOOD LOCKERS (BEVERAGE AND RTE)	7.20	1.99
EQUIPMENT INSTALLATION	0.91	0.25
MISCELLANEOUS HARDWARE	0.26	0.06
TRASH-BEV 1/1 VOL RATIO	6.24	1.74
RTE .25/1 VOL RATIO		
INSTALLATION TOTALS	14.6	4.04
TOTAL SYSTEM (LESS FOOD)	41.6	6.98

* Weight and Volume Figures are 1.3 x Calculated to allow for growth and contingency.

TABLE 9

3.3 System III

3.3.1 Food Types and Quantities

- Beverage

Food Wt. 1.23 oz.

Pkg. Wt. 0.50 oz.

1.73 oz.

Quantity 8 per man day x 42 man days = 336 Mission

Overage 5% = 16.8 Carry \longrightarrow $\frac{21}{357}$ Total

- RTE

Food Wt. 2.28 oz.

Pkg. Wt. .25 oz.

2.53 oz.

Quantity 4 per man day x 42 man days = 168 Mission

Overage 25% = 42 Carry \longrightarrow $\frac{49}{217}$ Total

- Rehydratable

Food Wt. 1.94 oz.

Pkg Wt. .50 oz.

2.44 oz.

Quantity 7 per man day x 42 man days = 294 Mission

Overage 5% = 14.6 Carry \longrightarrow $\frac{14}{308}$ Total

Food and Primary Packaging Weight Per Mission

- Beverage

1b.

Food 1.23 oz x 357 = 463.7 oz. = 29.0 lb.

Pkg .50 oz. x 357 = 188.5 oz = 11.8 lb.

642.2 oz. = 40.8 lb. 40.8

3.3.1 Cont'd

• RTE Bar		<u>Lb.</u>
Food	1.58 oz. x 217 = 342.9 oz. = 21.4 lb.	
Pkg.	.25 oz. x 217 = <u>54.2 oz.</u> = <u>3.4 lb.</u>	
	397.1 oz. = 24.8 lb.	24.8
• Rehydratable		
Food	1.94 oz. x 308 = 597.5 oz. = 37.4 lb.	
Pkg.	.50 oz. x 308 = <u>154.0 oz.</u> = <u>9.6 lb.</u>	
	751.5 oz. = 47.0 lb.	<u>47.0</u>
		112.6

TABLE 10
SYSTEMS SUMMARY
SYSTEM III

	Lb.	Ft ³
Food and Primary Package	140.	7.24
Logistics Liners	31.1	7.60
Water System - Hot & Cold	19.2	0.78
Wipes and Dispensers	9.75	0.30
Utensils - 6 Sets	1.70	0.14
Trays	11.6	1.17
Semi-active Oven	15.6	1.65
Equipment Totals	88.9	11.7
Food Lockers	14.2	3.97
Equipment Installation Structure	6.73	1.80
Utensil Stowage	0.39	(trays)
Tray Stowage	2.08	0.39
Trash Stowage	20.9	5.85
Work Surface	2.73	0.78
Miscellaneous Hardware	0.52	0.13
Galley Installation	47.6	12.9
Total Galley (Less Food)	136.5	24.6

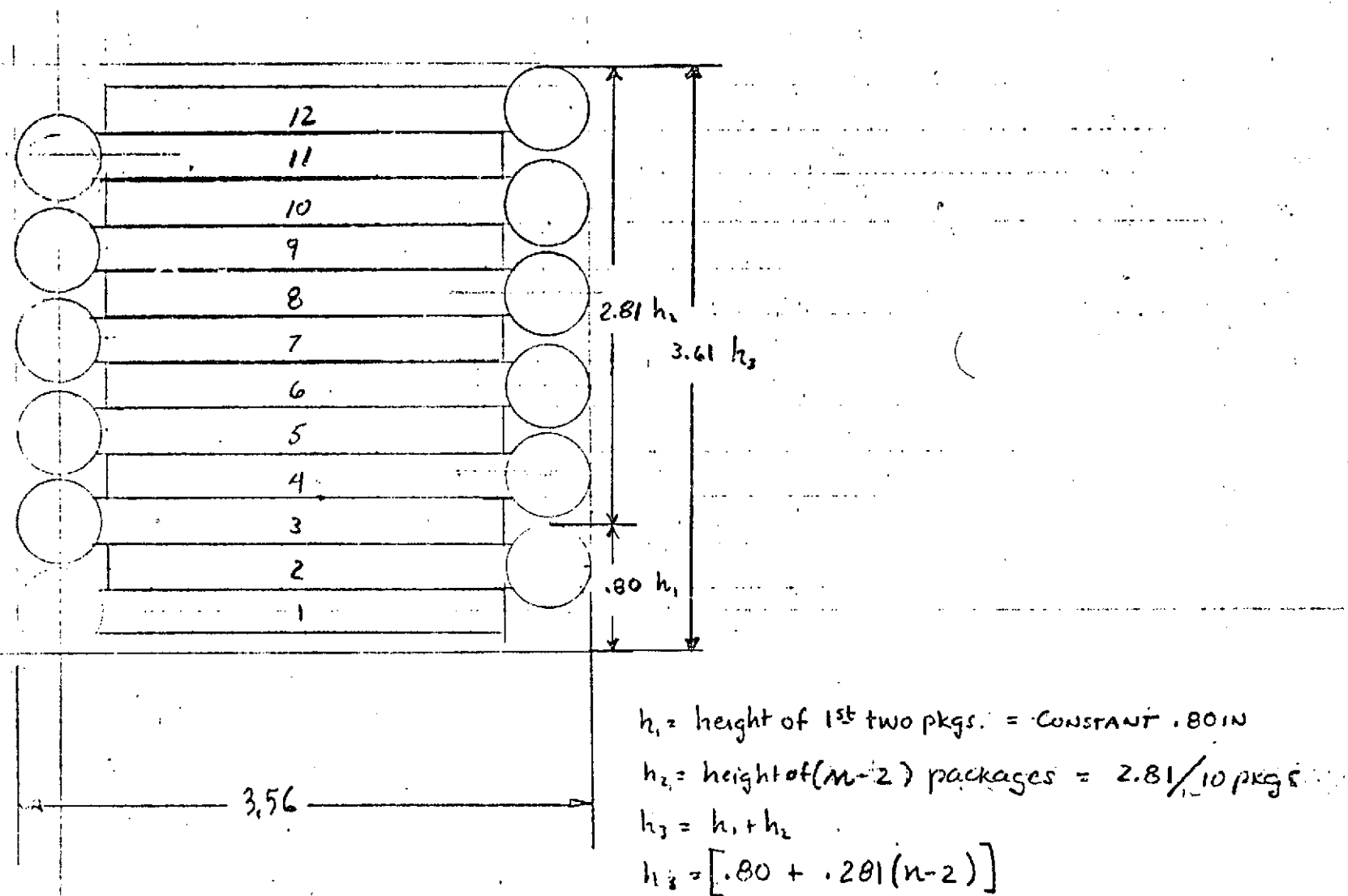


FIGURE 7
BEVERAGE PKG. EFFECTIVE STACKING DIMENSION

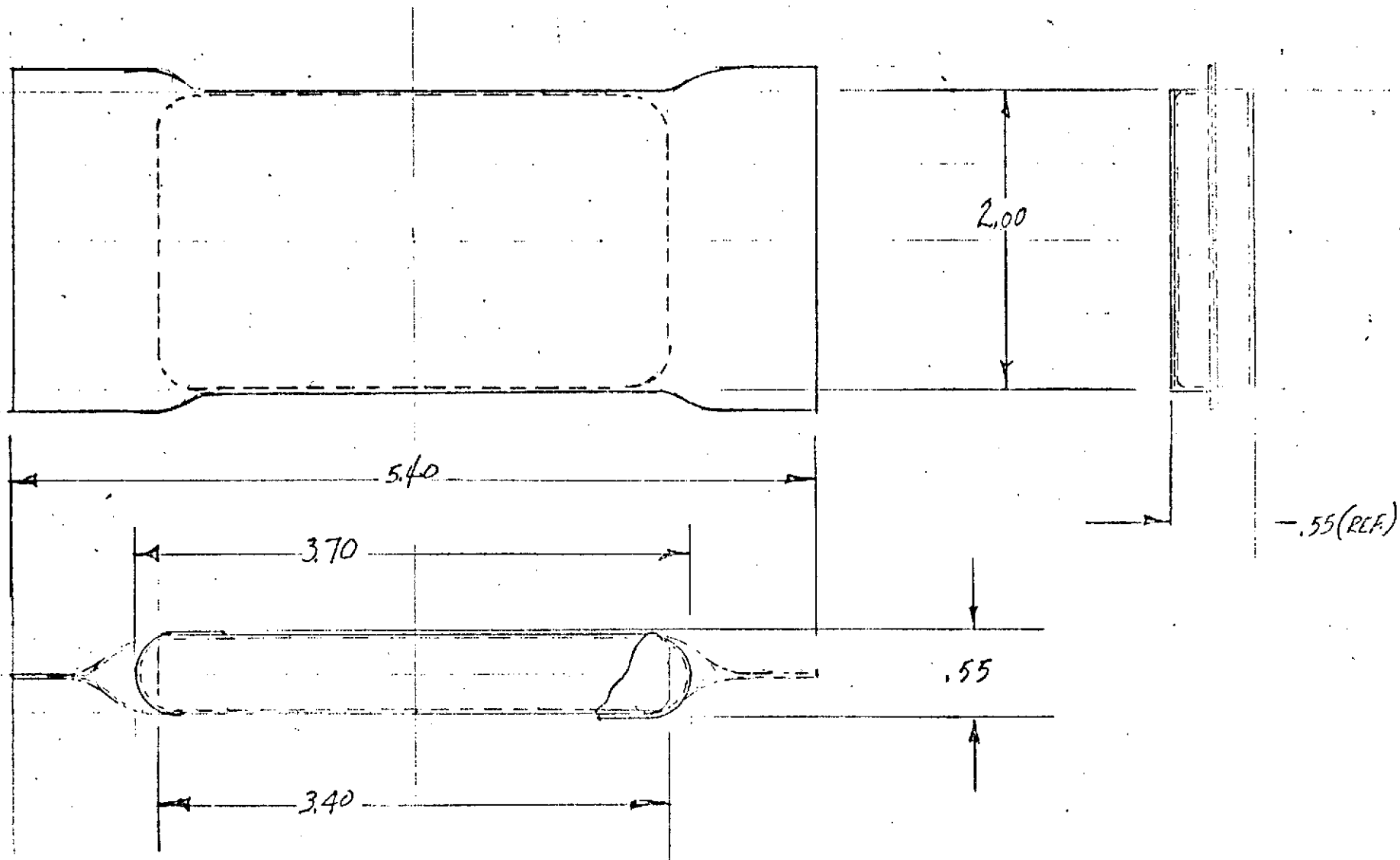


FIGURE 8
READY TO EAT PKG. (RTE)

3.3.1 Cont'd

Dimensional Analysis (Minimum Volume)

- Beverage Pack (Fig. 3.3.1-1)

Individual dimensions 3 in. x 5 in. x .28 in.

Effective stacking dimensions for packaging

$$V_n = 3.5 \text{ in.} \times 5.0 \text{ in.} \times [.281 (n-2) + .80] \text{ in.}$$

$$\text{Where } n = 357 \quad V_{\text{Bev}} = 1759 \text{ in}^3 \quad 1.02 \text{ Ft}^3$$

- RTE (Fig. 3.3.1-2)

$$V_{\text{RTE}} = (2.0 \text{ in.} \times 3.7 \text{ in.} \times .55 \text{ in.}) 217 = 884 \text{ in}^3 = 0.51 \text{ Ft}^3$$

- Rehydratable

Individual dimensions with Septum type valve and

fold down flexible top ready for stacking

(4.0 in. x 4.0 in. x 1.03 in.)

$$V_{\text{Rhyd}} = (4.0 \times 4.0 \times 1.03) 308 = 5075 \text{ in}^3 \quad \underline{\underline{2.94 \text{ Ft}^3}}$$

Total minimum volume of stacked food and primary

packaging -

$$4.57 \text{ Ft}^3$$

Arrangement

- Beverage and RTE packages are stacked according to Figures 3.3.1-3 and 3.3.1-4 in a crew day overwrap resealable bag 6.3 x 16.9 x 5.0 in.
- Rehydratable packages are stacked according to Figures 3.3.1-5 and 3.3.1-6 in a crew day overwrap resealable bag 12.6 x 14.9 x 4.0 in.

BEVERAGES & RTE

1 DAY OVERWRAP

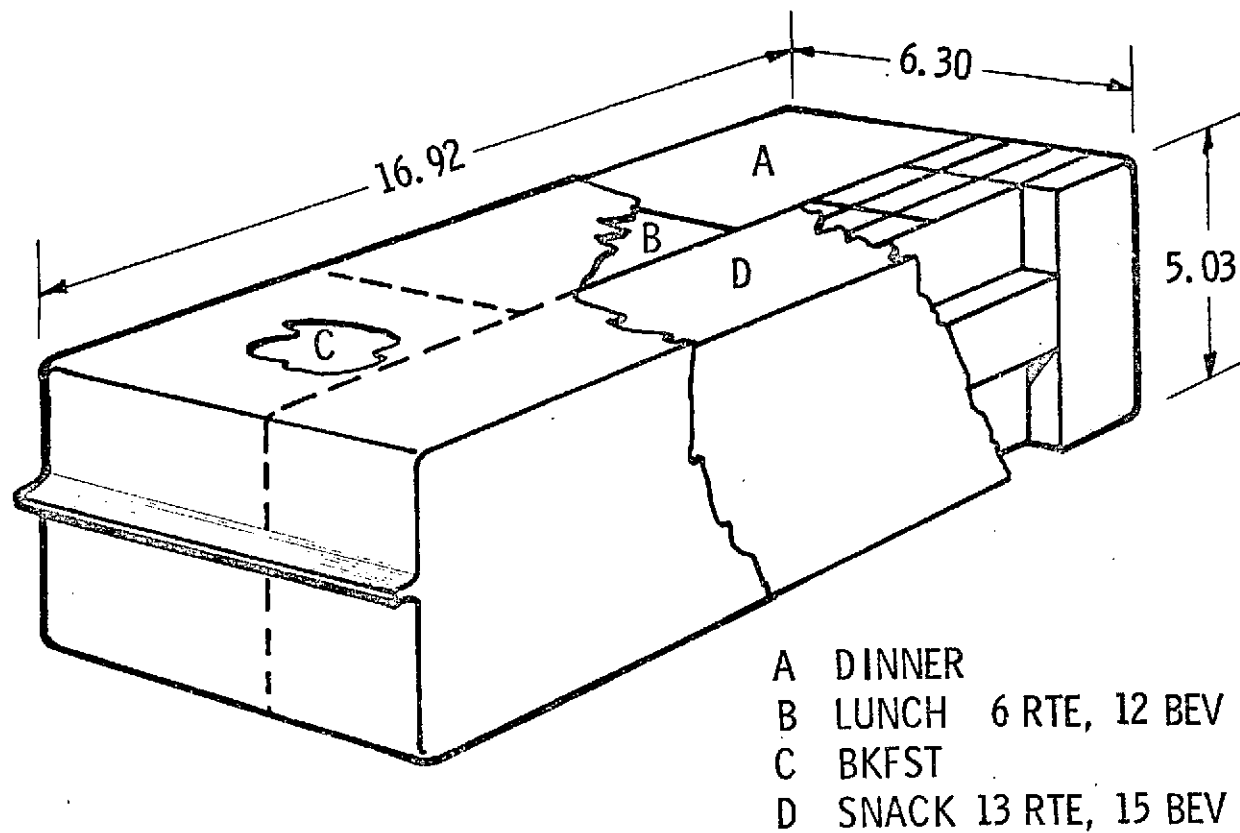
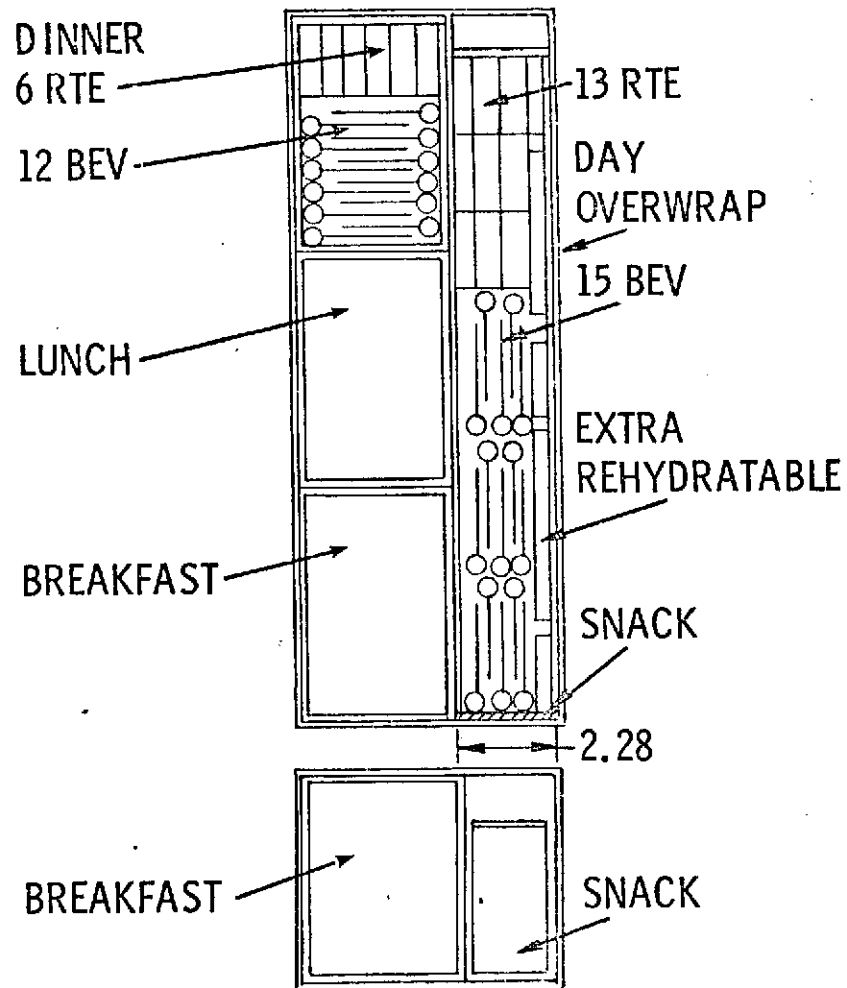


FIGURE 9

CREW MEAL PACKAGING PLAN

BEV & RTE ONE DAY SUPPLY



TYPICAL
LINER SHAPE

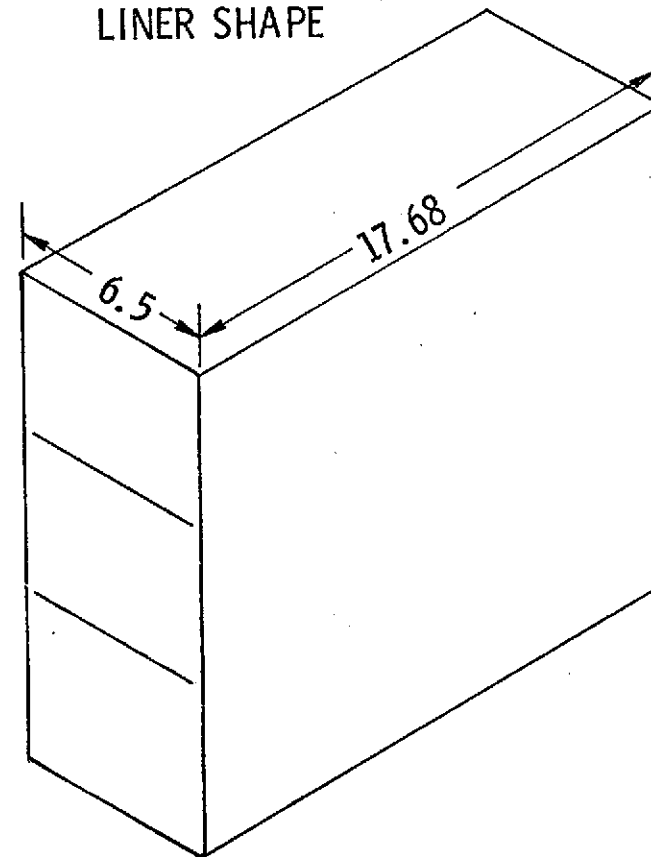


FIGURE 10

REHYDRATABLES

1 DAY OVERWRAP

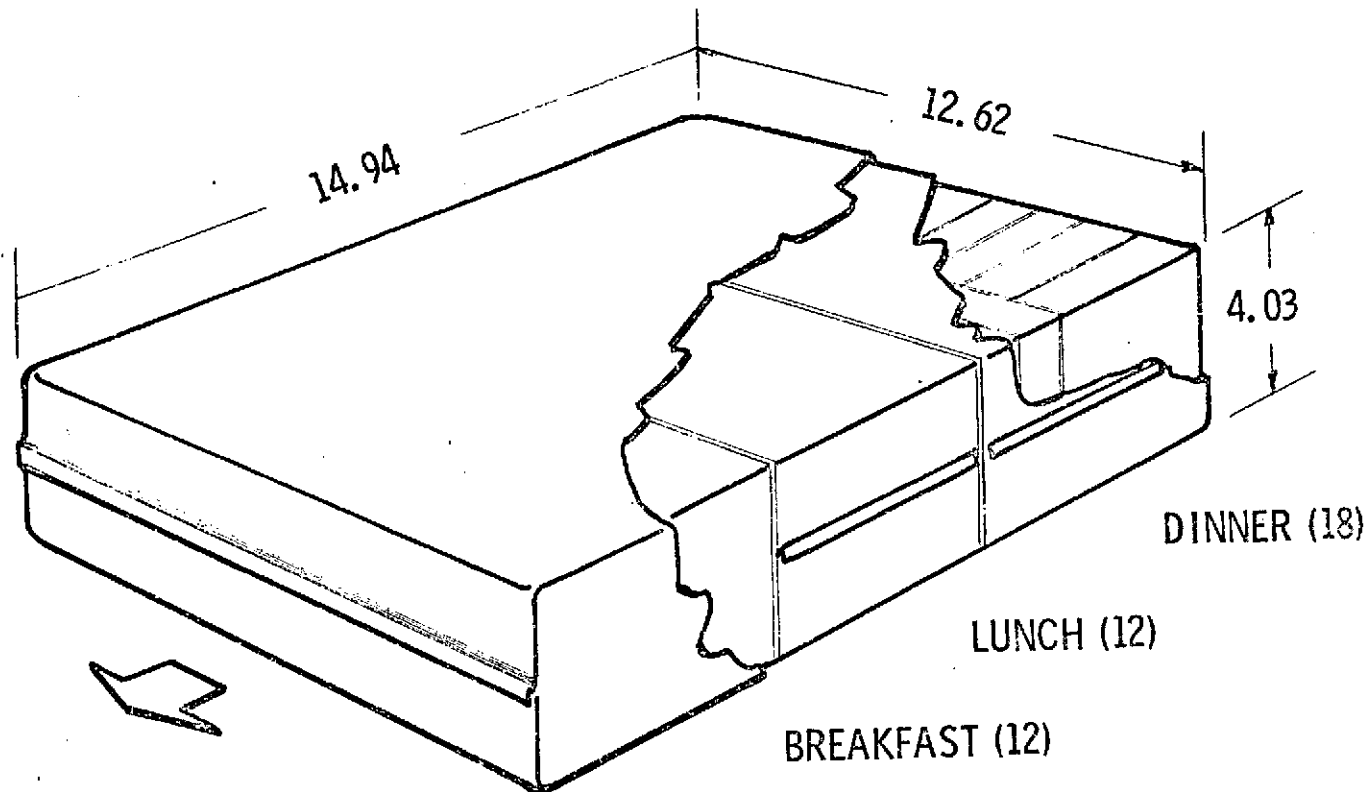


FIGURE 11

CREW MEAL PACKAGING PLAN

REHYDRATABLES (ONE DAY SUPPLY)

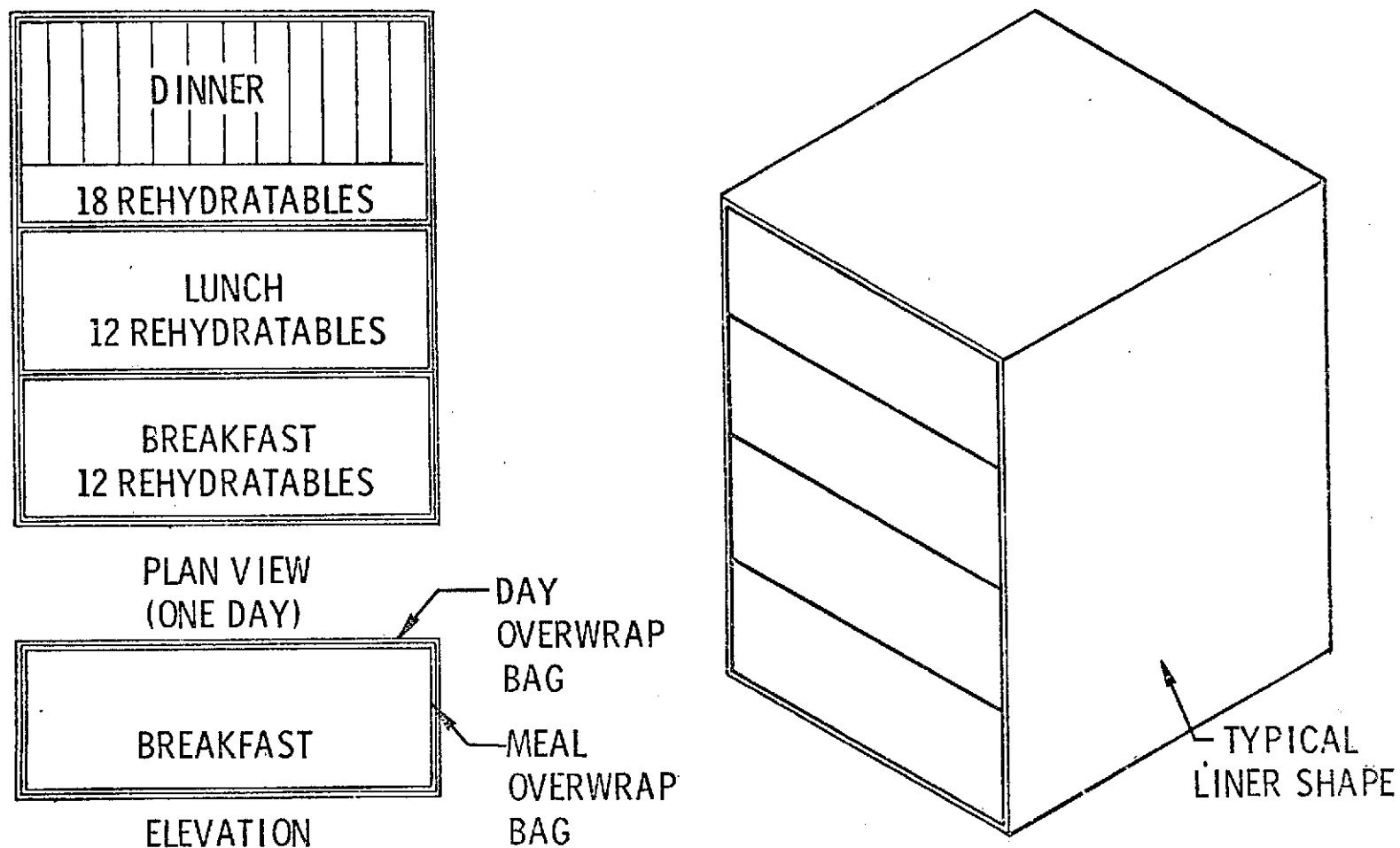


FIGURE 12

3.3.2 Equipment

Crew day overwraps are stowed in liners of four and three day capacities.

BEV/RTE (IN)				
	W	D	H ₄ Day	H ₃ Day
a Day Overwrap	6.3	16.9	5.0	5.0
b Spacers(.016)(n-1)			.48	.32
c n Layer Stack	6.3	16.9	20.5	15.3
d Clearance .062/S	.12	.12	.12	.12
e Inside Dimension	6.42	17.02	20.62	15.42
f Walls .062	.124	.124	.124	
g Outside Dimension	6.544	17.144	20.744	15.644

Rehydratable (IN)				
a Day Overwrap	12.6	14.9	4.0	4.0
b Spacers(.016)(n-1)			.48	.32
c n Layer Stack	12.6	14.9	17.1	12.3
d Clearance .062/S	.12	.12	.12	.12
e Inside Dimension	12.72	15.02	17.22	12.42
f Walls .062	.124	.124	.124	.124
g Outside Dimension	12.844	15.144	17.344	12.544

Material Densities

Liner Epox moulding compound glass fiber fill .068 lb/in³

Spacers TFE .078 lb/in³

Overwrap Polyeth .035 lb/in³

3.3.2 Cont'd

Weights

<u>Overwraps</u>	DAY	In ³	x ρ	x N=	LB.
Bev/RTE	6.3 in x 16.9 in. x 5.0 in	532.350			
	<u>- .012</u> <u>- .012</u> <u>- .012</u>				
	6.288 x 16.888 x 4.988	- 529.680			
	Density Volume	2.67	.035x =		.654
RHYD	12.6 in x 14.9 in x 5.0 in	750.960			
	<u>- .012</u> <u>- .012</u> <u>- .012</u>				
	12.588 x 14.888 x 3.988	- 747.391	.035x =		<u>.874</u>
	Density Volume	3.569			1.528
<u>Overwraps</u>	Meal 42 Bags ---				<u>3.992</u>

Overwraps Total W_O 5.520

Spacers Spacers Total W_S 1.400

	<u>Bev/RTE (IN³)</u>		<u>RHYD (IN³)</u>			
<u>LINERS</u>	4 Day	3 Day	4 Day	3 Day		
Outside Vol.	2393	1797	3455	2505		
-Inside Vol.	<u>2317</u>	<u>1737</u>	<u>3370</u>	<u>2437</u>		
ρ Volume	76	60	85	68		
x lb/in ³	<u>x.065</u>	<u>x.065</u>	<u>x.065</u>	<u>x.065</u>		
	4.94	3.90	5.52	4.42	W _L	<u>18.78</u>
	W _O + W _S + W _L = W _{Total} =					25.70

Stowage Summary

	<u>Quantity</u>	<u>lb.</u>	<u>In³</u>	<u>Ft³</u>
Food	892	87.8		
Packaging	892	24.8		
Overwraps	66	5.52		
Spacers	14	1.40		
Liners	4	18.78	10150	5.87
		<u>138.20</u>	<u>10150</u>	<u>5.87</u>

3.3.2 Cont'd

Water Systems Hot and Cold

1. Spherical Storage Tank 4 in. radius 2 ea.
2. Size for tubing valves and dispenser by allowing for
8 x 8 x 8 in cube for each system 2 ea.

Volume

• Hot Water System	8 in x 8 in x 8 in.	512 in ³	.30 Ft ³
Structure Penalty	<u>1.5 x 1.5 x 1.5 in.</u>		
	9.5 in x 9.5 in x 9.5 in	857 in ³	.50 Ft ³
• Cold Water System		System	.30 Ft ³
Same as above		Structure	.50 Ft ³
System Volume		.60 Ft ³	
Structure Penalty		<u>1.00 Ft³</u>	

<u>Weight*</u>	Hot	Cold	
Pump	3.5 lb.	3.5 lb.	
Water Tank	3.9 lb.	-	
Chiller	-	<u>3.92 lb.</u>	
	7.4	7.42	----- 14.8 lb.

*Estimates made to conform with heating analysis Appendix B
giving total weight of 14.8# for both systems.

Wipes and Dispensers (Wet wipes in individual packets)

- Large Galley Wipes 2/Meal x 6/Day
- Small Personal Wipes 4/Man Day

Wipes

Size folded in packet

- Large Approx. (6 x 3 x 0.16) Folded in Packet
- Small Approx. (2.2 x 3. x 0.12) Folded in Packet

3.3.2 Cont'd

Weight/Mission

- Large .075 lb. ea. x 42 = 3.15
- Small .013 lb. ea. x 168 = 2.18 lb.
- Total = 5.33 lb.

Dispensers Dimensional Volume

- Large 6 x 3 x 7 = 126 in³
- Small 5 x 5 x 11 = 275 in³
- Total = 401 in³ = .23 Ft³

Dispensers Weight Ref. MSC 01816

- Large 2.2 lb.
- Small 1.1 lb.

Stowage Volume Analysis

<u>Large Dispenser</u>	6.0 x 3.0 x 7.0	<u>126 in³</u>	<u>.07 Ft³</u>
Clearance .05/Surface	.1 .1 .1		
Structure .25/Surface	<u>.5 .5 .5</u>		
Overall Dimension	6.6 x 3.6 x 7.6	<u>181 in³</u>	<u>.10 Ft³</u>
Stowage Density Volume		55 in ³	.03 Ft ³
<u>Small Dispenser</u>	5.0 x 5.0 x 11.0	<u>275 in³</u>	<u>.16 Ft³</u>
Clearance .05/Surface	.1 .1 .1		
Structure .25/Surface	<u>.5 .5 .5</u>		
Overall Dimension	5.6 x 5.6 x 11.6	<u>365 in³</u>	<u>.21 Ft³</u>
Stowage Density Volume		90 in ³	.05 Ft ³
Total Installed Volume		546 in ³	.31
Total Dimensional Volume		<u>401 in³</u>	<u>.23</u>
Total Stowage Density Volume		145 in ³	.08 Ft ³
<u>Weight</u>	Small 1.10 lb Disp.	Large 1.10 lb. Disp.	
	<u>2.18 lb Wipes</u>	<u>3.15 lb. Wipes</u>	
	3.28	4.25	
Totals	Weight 7.5 lb.	Volume .23 Ft ³	

3.3.2 Cont'd

<u>Utensils - Six Sets</u>		Standard Size			
<u>Dimensions*</u>		W(in)	L(in)	H(in)	V(in ³)
Fork		1.00	7.25	0.75	5.43
Spoon		1.30	6.00	0.75	5.84
Scissor		1.95	6.30	0.25	3.07
Drawer ⁺		5.0	7.60	1.00	38.0

*Max. Dimension

+Part of Serving Tray

Stowage Volume Utilized as Tray Drawer

$$38.0 \text{ in}^3 \times 6 \text{ Trays} = 228 \text{ in}^3 = .132 \text{ Ft}^3$$

Weight (Ref. MSC-03909)

	Ea.	lb.
Fork	(6)	.42
Spoon	(6)	.30
Scissor	(6)	<u>.63</u>
		1.35 lb.

Trays (Figure 3.3.2-1)

Hot Insert Type - Three Hot Rehydratables	67 in ²
Self Contained Utensil Stowage Drawer	38 in ³
RTE Receptacle - Two Max.	
Condiment Recept. - Four Max	
Beverage Recept. - Two Max	
General Purpose Recept. - WASTATS, Wipes	
Magnetic Utensil Plate	33 in ²

TRAY ASSEMBLY

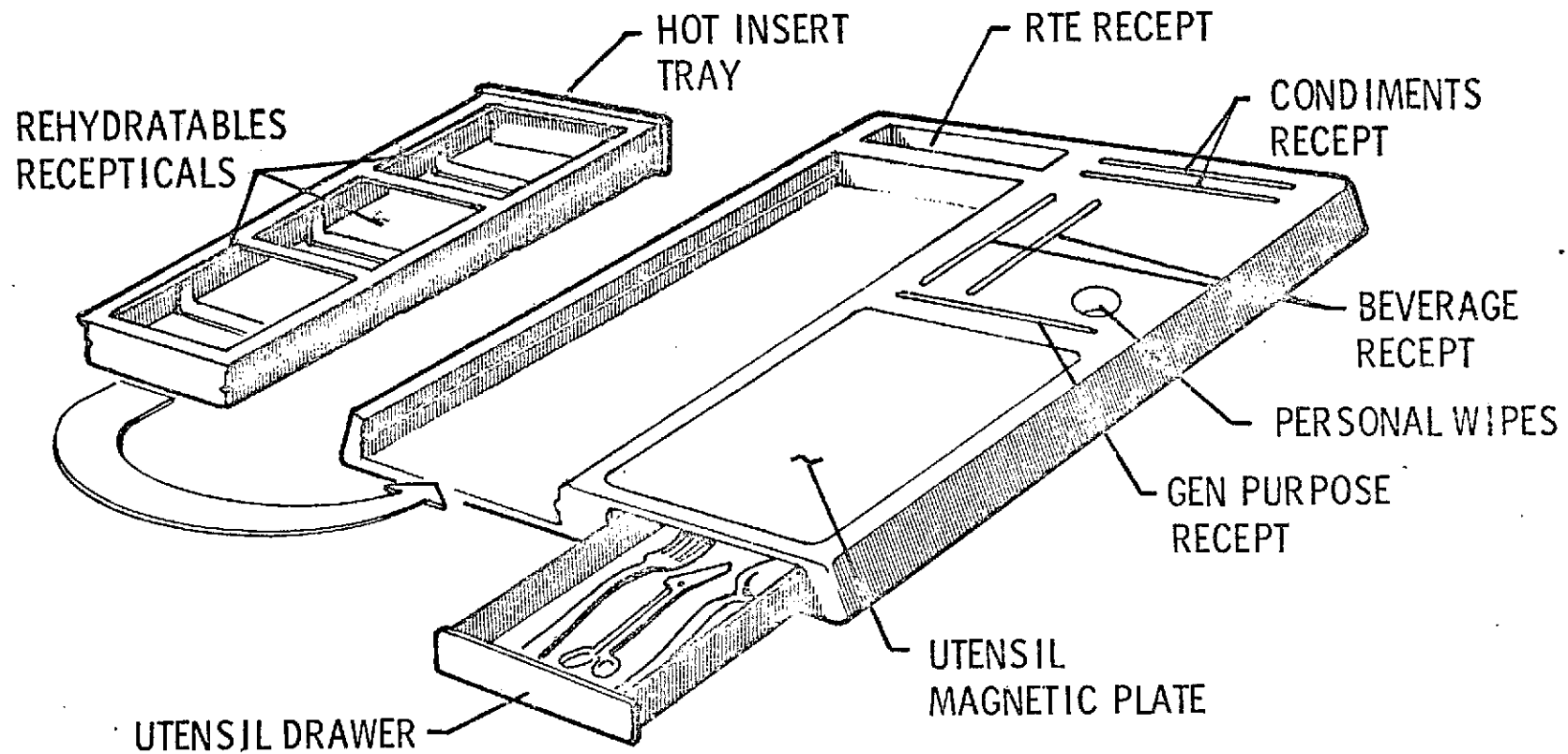


FIGURE 13

3.3.2 Cont'd

Trays Cont'd

	Dimensions					
	W	D	H	IN ²	IN ³	Ft ³
Overall	11.5	14.3	1.62	164.4	266	.154
Insert	5.2	12.9	1.2	67.1	30.5	
Drawer	5.0	7.6	1.0	38.0	38.0	
Utensil Surface	4.7	7.0		32.9	-	

Volume 6 Trays at .154 Ft³ ea. = .925 Ft³

Weight Estimate 1.50 lb. ea. x 6 ea. = 9.0 lb.

Semi Active Oven

Adapted from Hot Food Oven Mod. 541-1361

Mansfield Aircraft Products Co. , Mansfield, Ohio

	Dimensions				
	W(in)	D(in)	H(in)	IN ³	Ft ³
Cavity	6.75	13.50	13.00		
Overall	8.25	15.41	15.82	2005	1.17
Installed	10.3	17.5	17.9	3210	1.87

A tray retention device was mounted in the existing cavity enabling the oven to accept 6 hot insert trays.

Weight (Not actual for this oven - But optimum wt. based on calculation for 145° holding oven Heating Analysis

Appendix B.

Basic Oven 6.9 lb.

Heating Element 3.2

Racks 1.1

Controls 0.9
12.0 lb.

Structure Pen. 0.70 Ft³

3.3.3 Installation

<u>Food Lockers</u>					
	W IN	D IN	H IN	In ³	Ft ³
BEV/RTE 4 Day	6.544	17.144	20.744	2327	1.347
*Penalties	<u>2.1</u>	<u>3.1</u>	<u>2.1</u>		
	8.644	20.244	22.844	3997	<u>2.312</u>
				ΔV_1	.966
BEV/RTE 3 Day	6.544	17.144	15.644	1755	1.016
Penalties	<u>2.1</u>	<u>3.1</u>	<u>2.1</u>		
	8.644	20.244	17.744	3105	<u>1.797</u>
				ΔV_2	0.781
Rhyd 4 Day	12.844	15.144	12.544	2439	1.411
Penalties	<u>2.1</u>	<u>3.1</u>	<u>2.1</u>		
	14.944	18.244	19.444	5301	<u>3.067</u>
				ΔV_3	1.115
Rhyd 3 Day	12.844	15.144	12.544	2439	1.411
Penalties	<u>2.1</u>	<u>3.1</u>	<u>2.1</u>		
	14.944	18.244	14.644	3992	<u>2.310</u>
				ΔV_4	0.890
Structural ρ Vol.	.966	<u>Weight</u> = ρ Vol. x 3.6 lb/ft ³			
$\Sigma \Delta V$.781	3.852 x 3.6 lb/ft ³ = 13.86 lb.			
	1.115				
	<u>0.890</u>				

$$\Sigma \Delta V = \rho \text{ Vol.} = 3.852 \text{ Ft}^3$$

*Penalties	W	D	H
Clearance	.1	.1	.1
Structure	2.0	2.0	2.0
Access	<u>1.0</u>		
	2.1	3.1	2.1

3.3.3 Cont'd

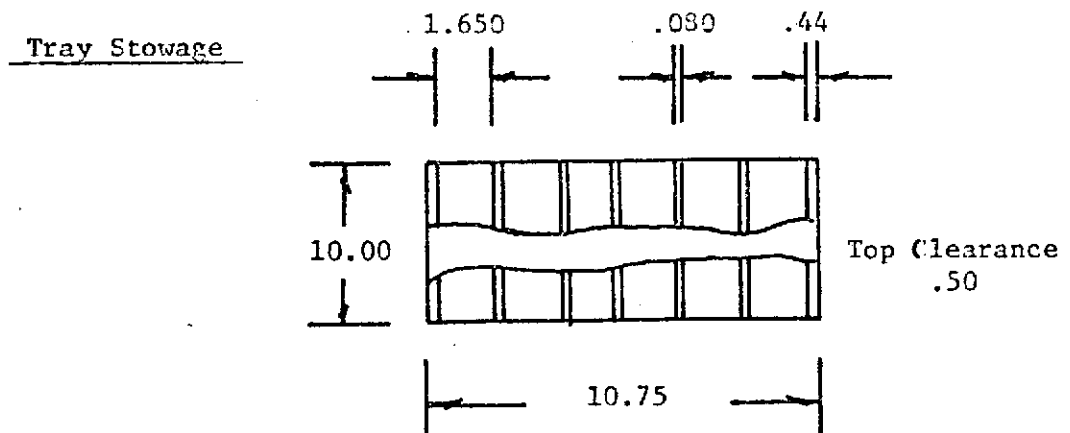
Equipment Installation Structure

Item	Installed Volume Ft ³	- Dimensional Volume Ft ³	Structural Penalty Ft ³
Oven	1.87	1.17	0.70
Water Hot	.50	.30	0.20
Water Cold	.50	.30	.20
Large Wipes Dispenser	.10	.07	.03
Small Wipes Dispenser	.21	.16	.05
		Structural Penalty	1.18*

Equipment installation structure weight equals structure
penalty (Ft³) x 3.6 lb/Ft³

$$1.18 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3 = 4.25 \text{ lb.}$$

* This is a significant reduction in structure penalty volume from the 1.39 Ft³ previously calculated and carried in the summary table as 1.80 Ft³ = 1.39 Ft³ x 130%. This result is realized by adoption of the updated production oven and re-design of the hot insert tray from a 4 insert A to 3 insert tray previous oven structure penalty was .91 versus present .70.



$$\text{Dimensional Volume of Trays} = .154 \text{ Ft}^3 \times 6 .92 \text{ Ft}^3$$

$$V = 10.75 \times 10.00 \times 15.25 = 1640 \text{ In}^3 = .95 \text{ Ft}^3$$

3.3.3 Cont'd

Tray Stowage Cont'd

Stowage Volume .95 Ft³ is penalty volume.

$$\text{Weight} = .95 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3 = 3.42 \text{ lb.}$$

Trash Stowage

Estimated Trash Stowage (One Day) Requirement

(Volume Recycling)

BEV/RTE Overwrap	6.30	x	16.92	x	5.03	=	536 In ³
Rhyd Overwrap	12.625	x	14.94	x	4.03	=	760 In ³
Liner Inside Dim.	18.90		16.92		5.03	=	1608 In ³ = .93 Ft ³
Installation	1.0		2.0		1.0	=	
	19.9		18.9		6.0	=	2260 in ³ = <u>1.3 Ft³</u>

Stowage Volume 1.3 Ft³ is penalty volume

$$\text{Weight } 1.3 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3 = 4.67 \text{ lb.}$$

(Non Volume Recycling)

	*Mission Dimensional Vol.	Trash Vol/Stor. Vol.	Trash Vol.
Beverage	1.02 Ft ³	1/1	1.02
RTE	0.51 Ft ³	.25/1	.13
Rhyd	2.94	1/1	<u>2.94</u>
			4.09 Ft ³

*Ref. 3.3.1

Total Trash Penalty Vol. 4.09 Ft³

$$\text{Weight } 4.09 \text{ Ft}^3 \times 3.6 \text{ lb/ft}^3 = 14.75 \text{ lb.}$$

Actual Mock-up Trash Stowage Pullout Drawer

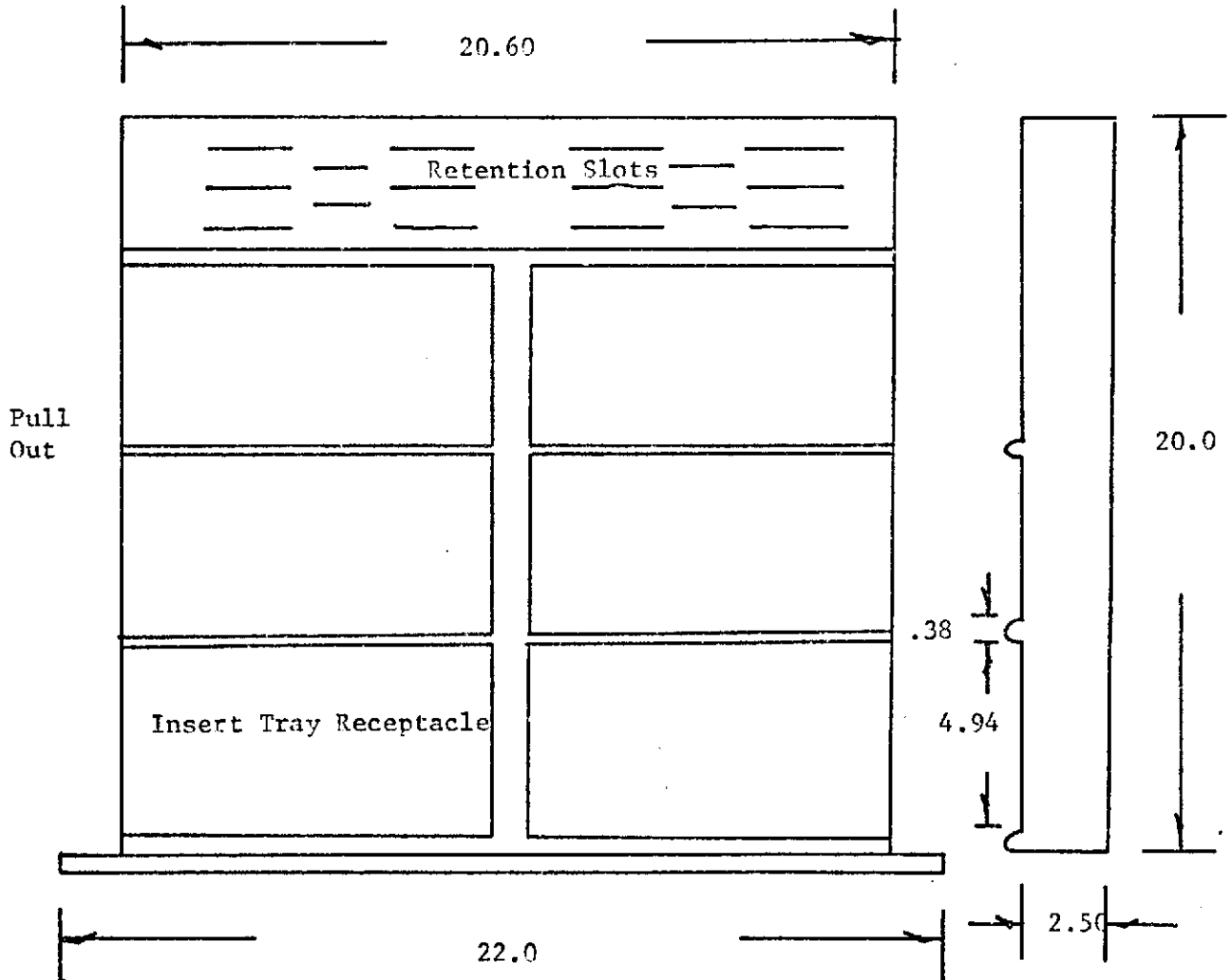
W	D	H	
9.84	20.00	14.94	= 2940 In ³ = 1.70 Ft ³

$$\text{Weight } 1.70 \text{ Ft}^3 \times 3.6 \text{ lb/ft}^3 = 6.12 \text{ lb.}$$

3.3.3 Cont'd

Work Surface Drawer

Pull out drawer provides positive retention for six hot insert trays on surface. Additional surface is provided for general purpose retention



$$V = 20.60 \times 20.00 \times 2.50 = 1030 \text{ in}^3 = .595 \text{ Ft}^3$$

$$W = .595 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3 = 2.15 \text{ lb.}$$

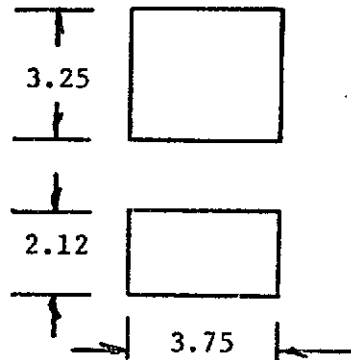
Miscellaneous Hardware

Estimate .5 lb. .13 Ft³

3.3.3 Cont'd

Contingency Food 16 Man Days

Air Force Emergency Ration Can



Required 16 Rations

Arrangement (Utilize 3 in. width)

1 pkg. wide = $1 \times 2.12 = 2.12$

4 pkg. deep = $4 \times 3.75 = 15.00$

4 pkg. high = $4 \times 3.25 = 13.00$

Weight 305 Gm each

$$305 \text{ Gm} \times \frac{1 \text{ lb.}}{453.59 \text{ gm}} \times 16 \text{ rations} = 10.75 \text{ lb.}$$

Dimensional Volume	W	D	H	In ³	Ft ³
1 x 4 x 4 Stack	2.12	15.00	13.00	413.4	.24
Overwrap .006/Surf.	.012	.012	.102		
Clearance .24/Surf.	.48	.48	.48		
Overall Dimensions	2.50	15.50	13.50	548.2	.32
Stowage Density Volume	.11 Ft ³				
<u>Overwrap Weight</u>	$[(2.132 \times 15.012 \times 13.012) - (413.4) \text{ in}^3] \times \frac{.035 \text{ lb.}}{\text{in}^3}$				
	= .016 lb.				

Stowed weight

Rations 10.75 lb.

Overwrap $\frac{.106 \text{ lb.}}{10.856 \text{ lb.}}$

Structure $.11 \text{ Ft}^3 \times 3.58 \text{ lb/Ft}^3 = .394 \text{ lb.}$

3.3.3 Cont'd

Condiments

Allocated dimensions

Available Dimensions 3.5 W x 4 H x 21 D = 294 In^3 .67 Ft^3

Required	Quantity	Wt.Ea. Pkg.	Oz.	Lb.
Catsup	32	.4 oz.	12.8	
Mustard	21	.4 oz.	12.4	
Salt	108	.1 oz.	10.8	
Pepper	63	.1 oz.	6.3	
Spices	63	.1 oz.	6.3	
Sauces	45	.4 oz.	<u>18.0</u>	
			66.6	4.16 lb.

3.4 System IV

3.4.1 Food Types and Quantities

- Beverage (Sky-lab type bellows container) 350/Mission
 - Food Weight 1.23 oz. ea.
 - Pkg. Weight 1.00 oz. ea.
 - 2.23 oz. ea.
- RTE (Ready to Eat) Bar (flight qualified) 175/Mission
 - Food Weight 1.58 oz. ea.
 - Pkg. Weight .25 oz. ea.
 - 1.83 oz. ea.
- Rehydratable (Rectangular development pkg.) 266/Mission
 - Food Weight 1.94 oz. ea.
 - Pkg. Weight .50 oz. ea.
 - 2.44 oz. ea.
- Refrigerated (Rectangular Development Pkg.) 48/Mission
 - Food Weight 7.40 oz. ea.
 - Pkg. Weight .50 oz. ea.
 - 7.90 oz. ea.

Food and Primary Package Weight per Mission

- Beverage
 - Food Weight 1.23 oz. ea. x 350 = 430.5 oz. = 26.90 lb.
 - Pkg. Weight 1.00 oz. ea. x 350 = 350.0 oz. = 21.88 lb.
 - Total Beverage 2.23 oz. ea. x 350 780.5 oz. = 48.78 lb.
- RTE Bar
 - Food Weight 1.58 oz. ea. x 175 = 276.5 oz. = 17.28 lb.
 - Pkg. Weight .25 oz. ea. x 175 = 43.8 oz. = 2.74 lb.
 - Total RTE 1.83 oz. ea. x 175 = 320.3 oz. = 20.02 lb.

SYSTEMS SUMMARY

SYSTEM IV

FOOD AND PRIMARY PACKAGE	LB	FT ³
	172.	7.68
CASE 1 - NO MEAL CHOICE	28.6	7.41
LOGISTICS LINERS		
CASE 2 - 1 MEAL CHOICE	59.7	12.7
CABINETS W. DRAWERS AND REFRIG. LINER		
WATER SYSTEMS - HOT AND COLD	19.2	0.78
WIPES AND DISPENSERS	9.75	0.30
UTENSILS - 6 SETS	1.82	0.16
TRAYS (HOT INSERT TYPE) - 6	9.82	1.10
SEMI-ACTIVE OVEN	15.6	1.65
REFRIGERATOR	35.4	1.72
EQUIPMENT TOTALS		
CASE 1	122.	13.2
CASE 2	153.	18.5

TABLE 11

SYSTEMS SUMMARY

SYSTEM IV (CONT'D)

	LB	FT ³
CASE 1 - FOOD LOCKERS	15.1	4.17
CASE 2 - CABINET W. DRAWERS	*(59.7)	*(12.7)
EQUIPMENT INSTALLATION STRUCTURE	10.0	2.77
UTENSIL STOWAGE	0.39	0.09
TRAYS STOWAGE	1.87	0.52
WORK SURFACE	2.34	0.66
MISCELLANEOUS HARDWARE	0.52	0.16
GALLEY INSTALLATION		
CASE 1	61.7	17.1
CASE 2	46.6	12.9
TOTAL GALLEY (LESS FOOD)		
CASE 1	**184.	30.3
CASE 2	200.	31.5

* NOT ADDITIVE

** CASE 1 CHOSEN FOR STUDY PURPOSES

TABLE 11
(Cont'd)

3.4.1 Cont'd

- Rehydratable

Food Weight 1.94 oz. ea. x 266 = 516.0 oz. = 32.25 lb.

Pkg. Weight .50 oz. ea. x 266 = 133.0 oz. = 8.31 lb.

Total Rhyd. 2.44 oz. ea. x 266 = 649.0 oz. = 40.56 lb.

- Refrigerated

Food Weight 7.40 oz. ea. x 48 = 355.2 oz. = 22.20 lb.

Pkg. Weight .50 oz. ea. x 48 = 24.0 oz. = 1.50 lb.

Total Refrig. 7.90 oz. ea. x 48 = 379.2 oz. = 23.70 lb.

- Total Food & Primary Pkg./Mission Food - 98.63

Pkg. 34.43

Total 133.06 lb.

Arrangement

BEV/RTE Figure 14

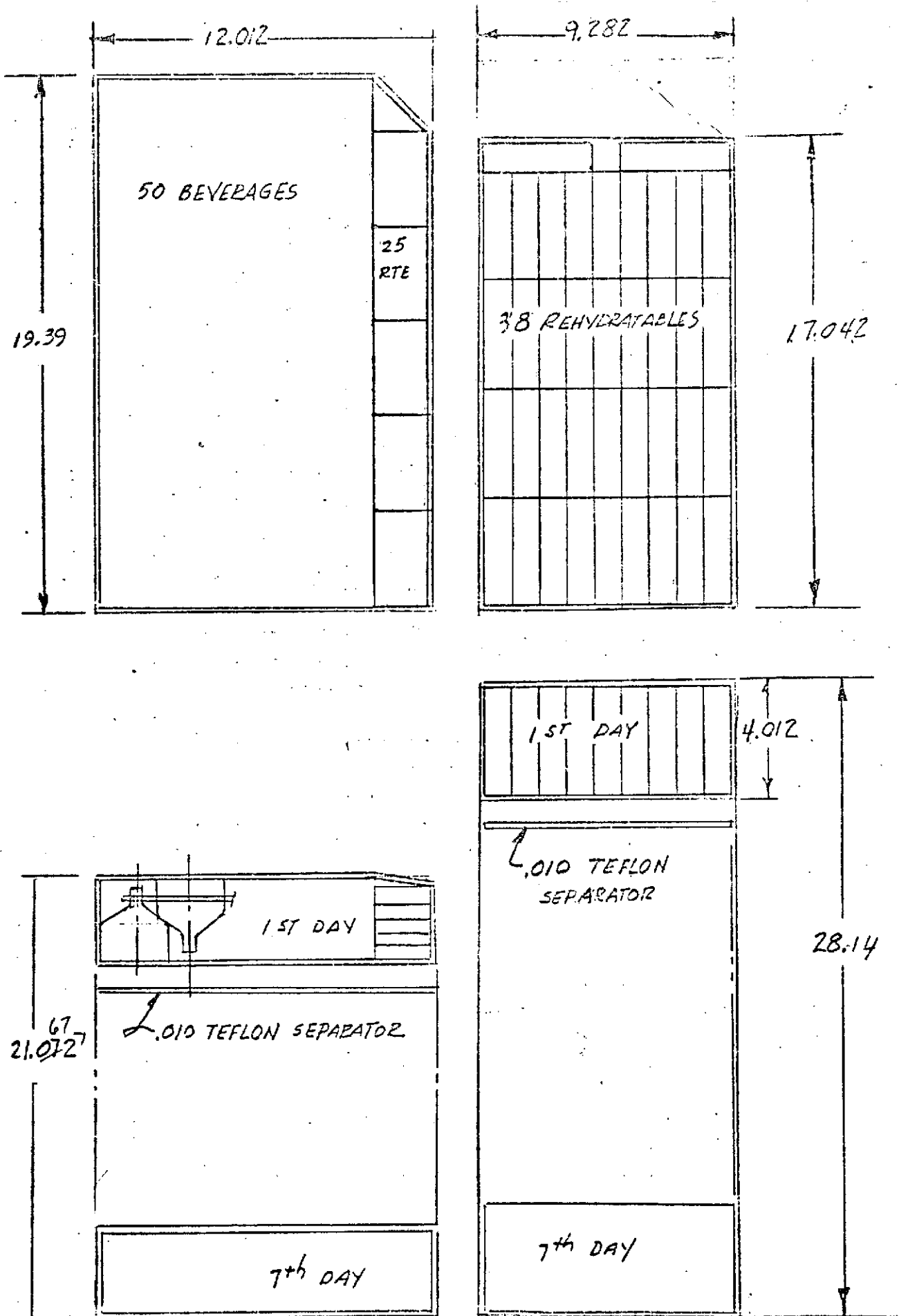
The crew day supply of 50 beverage containers and 25 RTSs is overwrapped. Seven overwraps comprising the mission Bev/RTE requirement are brought aboard in a logistics liner and arranged in a cabinet for use on a one overwrap per day basis.

Rehydratables Figure 14

The crew day supply of 38 rehydratables is overwrapped. Seven overwraps comprising the mission rehydratable requirement are brought aboard in a logistics liner and arranged in a cabinet for use on a one overwrap per day basis.

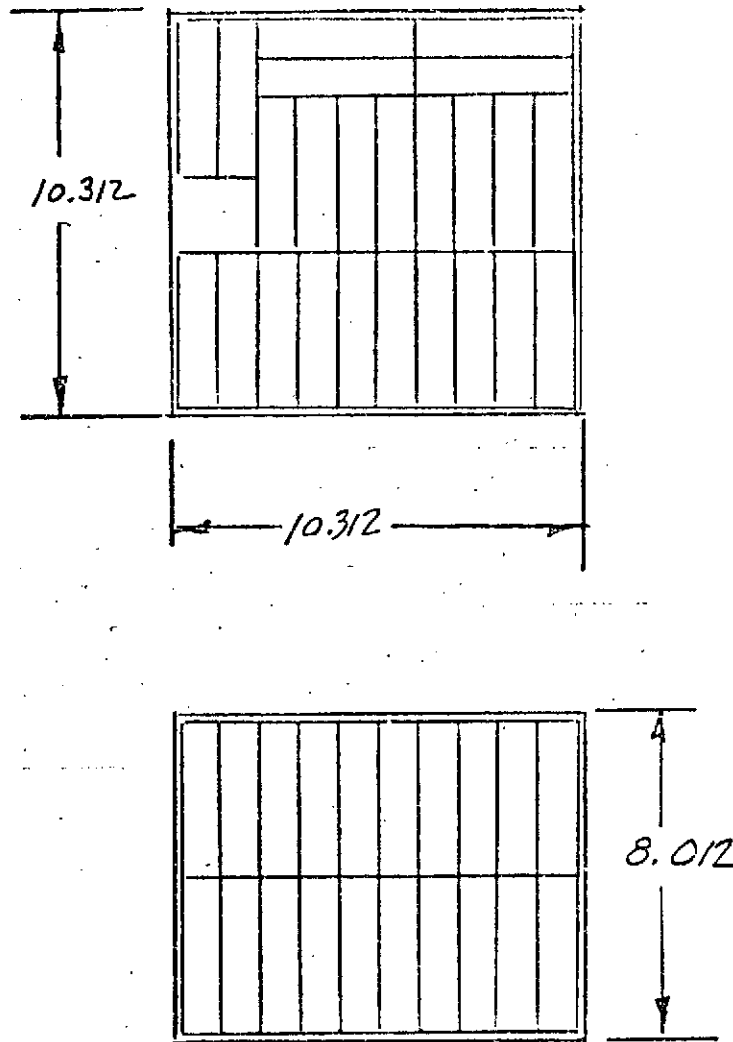
Refrigerated Food Figure 15

The mission requirement of 48 refrigerated food items is overwrapped. One overwrap is packaged in a logistics liner to be kept refrigerated at all times.



BEV/RTE AND RHVD ARRANGEMENTS

FIGURE 14



48 REFRIGERATED PACKAGES

FIGURE 15

REFRIGERATED FOOD PKG. ARRANGEMENTS

3.4.1 Cont'd

Dimensional Analysis

<u>BEV/RTE</u>	<u>W</u>	<u>D</u>	<u>H</u>	<u>In³</u>	<u>Ft³</u>
a ₁ 50 BEV/25 RTE	12.000	19.378	2.989		
Overwrap .006/S.	<u>.012</u>	<u>.012</u>	<u>.012</u>		
b ₁ One Day Supply	12.012	19.390	3.001		

Rhyd

a ₂ 38 Rhyd Pkg.	9.270	17.030	4.000		
Overwrap .006/S.	<u>.012</u>	<u>.012</u>	<u>.012</u>		
b ₂ One Day Supply	9.282	17.042	4.012		

Refrigerated

a ₃ 48 Refrg. Pkg.	10.300	10.300	8.000		
Overwrap .006/S	<u>.012</u>	<u>.012</u>	<u>.012</u>		
b ₃ Mission Supply	10.312	10.312	8.012		

3.4.2 Stowage Equipment

BEV/RTE Liner

a ₁ Food-Day Layer	12.000	19.378	2.989	695.	.404
b ₁ Overwrapped Layer	12.012	19.390	3.001	699.	
c ₁ Spacers .010 ea.	12.012	19.390	.060	14.	
d ₁ Seven Layer Stack	12.012	19.390	21.067	4907.	2.84
e ₁ Clearance .062/S	.124	.124	.124		
f ₁ Inside Dimension	12.136	19.514	21.191	5018.	
g ₁ Liner Thickness .060/S	.120	.120	.120		
h ₁ Outside Dimension	12.256	19.634	21.311	5128	2.97

3.4.2 Cont'd

Rehydratable Food Liner

	W	D	H	In ³	Ft ³
a ₂ Food-Day Layer	9.270	17.030	4.000	632.	
b ₂ Overwrapped Layer	9.282	17.042	4.012	635.	.367
c ₂ Spacers .010 ea.	9.282	17.042	.062	10.	
d ₂ Seven Layer Stack	9.282	17.042	28.144	4452.	2.58
e ₂ Clearance .062/S	.124	.124	.124		
f ₂ Inside Dimension	9.406	17.166	28.268	4564.	
g ₂ Liner Thickness .060/S.	.120	.120	.120		
h ₂ Outside Dimension	9.526	17.286	28.388	4674.	2.70

Rehydratable Food Cabinet - See Separate Analysis, End
of Section V.

Refrigerated Food Liner

	W	D	H	In ³	Ft ³
a ₃ Food-Mission Quan.	10.300	10.300	8.000	849.	
b ₃ Overwrapped Layer	10.312	10.312	8.012	852.	.493
e ₃ Clearance .062/S	.124	.124	.124		
f ₃ Inside Dimension	10.436	10.436	8.136	886.	
g ₃ Liner Thickness .060/S	.120	.120	.120		
h ₃ Outside Dimension	10.556	10.556	8.256	920.	.532

Materials Densities

- Liners - Epoxy moulding compound-glass fiber fill .068 lb/in.
- Spacers - TFE .078 lb/in³
- Overwraps - Polyeth .035 lb/in³

3.4.2 Cont'd

Material Weights

• Overwraps	.035 lb/in ³	In ³ x $\frac{n}{7}$ x ρ = lb.
BEV/RTE	(b ₁ -a ₁) In ³ (699 - 695) =	4 7 x .035 = .98
Rhyd	(b ₂ -a ₂) In ³ (635 - 632) =	3 7 x .035 = .74
Refrig	(b ₃ -a ₃) In ³ (852 - 849) =	3 1 x .035 = .10
• TFE Spacers	.078 lb/in ³	
BEV/RTE	c ₁ In ³	14 x 6/6 x .078 = 1.09
Rhyd	c ₂ In ³	10 x 6/6 x .078 = .78
Refrig	None	- - - -
• Liners	.068 lb/in ³	
BEV/RTE	(h ₁ -f ₁) In ³ (5128-5018)	110 x 1 x .068 = 7.48
Rhyd	(h ₂ -f ₂) In ³ (4674-4564)	110 x 1 x .068 = 7.48
Refrig.	(h ₃ -f ₃) In ³ (920 -886)	34 x 1 x .068 = 2.31

Food and Primary Packaging

	<u>lb.</u>	<u>Ft³</u>
Weight (pa 1)	133.6	
Volume:		
Bev/RTE	2.84	
Rhyd.	2.58	
Refrigerated	<u>.493</u>	
	5.9	

Equipment Summary

Case 1 Logistics Liners (No meal choice system)

Bev/RTE Liner	7.48 lb.	
Overwraps	.98 lb.	
Spacers	<u>1.09 lb.</u>	
	9.55 lb.	2.97 Ft. ³ (Dimensional Vol.)

3.4.2 Cont'd

Equipment Summary Cont'd

Rhyd Food Liner	7.48 lb.	
Overwraps	.74 lb.	
Spacers	<u>.78 lb.</u>	
	9.00 lb.	2.97 Ft ³ (Dimensional Vol.)
Refrig. Food Liner	2.31 lb.	
Overwraps	.10 lb.	
Spacers (none)	<u>-</u>	
	2.41 lb.	(.53 Ft ³) Charged to refrig.
	<u> </u>	<u> </u>
Liner Summary	21.96 lb.	5.67 Ft ³

Case 2 Cabinet with BEV/RTE and Rhyd food drawers plus weight of refrigerator liner.

Equivalent to 1 meal choice analysis presented in Vol. II Appendix D Package & Stowage Analysis

Weight	Volume		
Cabinet	43.5 lb.	9.79 Ft ³	
Refrig. Liner	<u>2.41</u>	<u>-</u>	
	45.9	9.8 Ft ³	
		Lb.	Ft ³
Hot and Cold Water Systems		14.8 lb.	.60 Ft ³
Same as System III			
Wipes and Dispensers			
Same as System III			
Large Wipes		3.15 lb.	
Small Wipes		<u>2.18 lb.</u>	
		5.33 lb.	

3.4.2 Cont'd

Hot & Cold Water Systems Cont'd

Large Dispenser 1.1 lb.

Small Dispenser 1.1 lb.

2.2 lb. .23 Ft³

Utensils (6 sets as per System III) 1.35 lb. .132 Ft³

Trays (Hot insert type as per Sys. III) 9.0 lb. .925 Ft³

Semi-active Oven as per System III 12.0 lb. 1.17 Ft³

Refrigerator - Thermoelectric Ref. Appendix C

Use 14 x 10 x 9 cavity from Cooling Systems Analysis
Volume II Appendix C as analog to cavity required for
refrigerated logistics liner.

Food 10.5 x 10.5 x 8.25

Clearance .25 x .25 x .25

10.75 10.75 8.5

Weight based upon super insulation 27.2 lb.

Volume based upon super insulation 1.32 Ft³

3.4.3 Installation

<u>Food Lockers</u>				In^3	Ft^3
Rhyd Liner				9.526 x 17.286 x 28.388	4674 2.70
Penalties	Clearance .05/S	.1	.1	.1	
	Structure 1.0/S.	2.0	2.0	2.0	
	Access 1.0/F		1.0		
Installed				11.626 20.386 30.488	7725 4.47
Beverage				12.256 x 19.634 x 21.311	5128 2.97
Penalties				2.1 3.1 2.1	
Installed				14.356 22.734 23.411	7641 4.42
Refrigerator Liner - Assigned to refrigerator					

Q Volumes

Rehydratable	$V = 3051 \text{ in}^3$	1.76 Ft^3
	$V = 2513 \text{ in}^3$	1.45 Ft^3

Weight

Rehydratable food locker	$1.76 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3 = 6.3 \text{ lb.}$
BEV/RTE Food Locker	$1.45 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3 = \underline{5.2 \text{ lb.}}$
	$\underline{\underline{11.5 \text{ lb.}}}$
	3.21 Ft^3

Equipment Installation

	Installation Penalty x $3.6 \frac{\text{lb}}{\text{Ft}^3}$	Wt.
Water System (System III)	$.4 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3$	1.44
Oven (System III)	$.7 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3$	2.52
Wipes Dispensers (Systems III)	$.08 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3$.29
Refrigerator	$\underline{.75 \text{ Ft}^3} \times 3.6 \text{ lb/Ft}^3$	$\underline{2.70}$
	1.93 Ft^3	6.95 lb.

3.4.3 Cont'd

<u>Utensil Stowage</u>	(As per System III)	(In tray)	
<u>Tray Stowage</u>	(As per System III)	3.42 lb.	.95 Ft ³
<u>Trash Stowage</u>			
	Vol. (Ft ³)	Compaction Ratio	Trash Vol.
Beverage	2.36	1.5/1*	3.54 Ft ³
RTE	0.48	.25/1	.12 Ft ³
Rhyd	2.58	1/1	2.58 Ft ³
Refrig.	0.49	1/1	.49 Ft ³
			6.73 Ft. ³

*Bev. compaction ratio 1.5/1 based upon loss stacking efficiency.

Trash stowage Weight Penalty

$$6.73 \text{ Ft}^3 \times 3.6 \text{ lb/Ft}^3 = 24.22 \text{ lb.}$$

<u>Work Surface</u>	(As per System III)	2.15 lb.	.595 Ft ³
<u>Miscellaneous Hardware</u>			
Estimate		0.5 lb.	.13 Ft ³

3.5 System V

3.5.1 Food Types and Quantities per Mission

- Beverage (Sky-lab type bellows container) 350/Mission
 - Food Weight 1.23 oz. ea.
 - Pkg. Weight 1.00 oz. ea.
 - 2.23 oz. ea.
- RTE (Ready to Eat) Bar (Flight Qualified) 175/Mission
 - Food Weight 1.58 oz. ea.
 - Pkg. Weight .25 oz. ea.
 - 1.83 oz. ea.
- Rehydratable (Rectangular-development pkg.) 175/Mission
 - Food Weight 1.94 oz. ea.
 - Pkg. Weight .50 oz. ea. (Valve included)
 - 2.44
- Wet Pack (Rectangular development pkg.) 49/Mission
 - Food Weight 7.40 oz. ea.
 - Pkg. weight .50 oz.
 - 7.90 oz. ea.
- Refrigerated (Rectangular development pkg.) 48/Mission
 - Food Weight 7.40 oz. ea.
 - Pkg. Weight .50 oz. ea.
- Frozen (Rectangular development pkg.) 48/Mission
 - Food Weight 7.40 oz. ea.
 - Pkg. Weight .50 oz. ea.
 - 7.90 oz. ea.

SYSTEM V

FOOD AND PRIMARY PACKAGE	LB	FT ³
	217.	7.76
CASE 1 - NO MEAL CHOICE	29.2	6.76
LOGISTICS LINERS		
CASE 2 - 1 MEAL CHOICE	62.8	12.7
CABINET W DRAWERS AND REFRIG. LINER AND FROZEN LINER		
CASE 3 - FULL MEAL CHOICE	108.	14.0
CABINET W DRAWERS AND REFRIG. LINER AND FROZEN LINER		
WATER SYSTEM - HOT AND COLD	19.2	0.78
WIPES AND DISPENSERS	9.75	0.30
UTENSILS - 6 SETS AND PREPARATION UTENSILS	1.95	0.17
TRAYS (HOT INSERT TYPE) 6	11.6	1.26
HOT AIR CONVECTION OVEN	53.7	1.90
REFRIGERATOR	35.4	1.72
FREEZER 0 F	45.8	1.72
TRASH COMPACTOR	19.5	0.38
EQUIPMENT TOTALS	CASE 1	226.
	CASE 2	260.
	CASE 3	305.
		15.0
		21.0
		22.4

TABLE 12

SYSTEM V (CONT'D)

	LB	FT ³
CASE 1 FOOD LOCKERS	12.9	3.59
CASE 2 CABINET W DRAWERS	*(62.8)	*(12.7)
CASE 3 CABINET W DRAWERS	*(108.)	*(14.0)
EQUIPMENT INSTALLATION STRUCTURE	15.1	4.20
UTENSIL STOWAGE	0.39	0.09
TRAYS STOWAGE	1.87	0.52
TRASH STOWAGE	31.9	8.85
WORK SURFACE	2.34	0.66
MISCELLANEOUS HARDWARE	0.58	0.17
GALLEY INSTALLATION		
CASE 1	65.1	18.1
CASE 2	52.2	14.5
CASE 3	52.2	14.5
TOTAL GALLEY (LESS FOOD)		
CASE 1	**291.	33.1
CASE 2	312.	35.4
CASE 3	357.	36.7

*NOT ADDITIVE

**CASE 1 CHOSEN FOR STUDY PURPOSES

3.5.1. Cont'd

Food and Primary Package Weight per Mission

- Beverage (350)

Food Weight	$1.23 \text{ oz.} \times 350 = 430.5 \text{ oz.} = 26.90 \text{ lb.}$
Pkg. Weight	$\underline{1.00 \text{ oz.} \times 350 = 350.0 \text{ oz.} = 21.88 \text{ lb.}}$
Total	$2.23 \text{ oz} \times 350 = 780.5 \text{ oz.} = 48.78 \text{ lb.}$

- RTE Bar (175)

Food Weight	$1.58 \text{ oz.} \times 175 = 276.5 \text{ oz.} = 17.28 \text{ lb.}$
Pkg Weight	$\underline{.25 \text{ oz.} \times 175 = 43.8 \text{ oz.} = 2.74 \text{ lb.}}$
Total	20.02 lb.

- Rehydratable (175)

Food Weight	$1.94 \text{ oz.} \times 175 = 339.5 \text{ oz.} = 21.22 \text{ lb.}$
Pkg. Weight	$\underline{.50 \text{ oz.} \times 175 = 87.5 \text{ oz.} = 5.46 \text{ lb.}}$
Total	26.68 lb.

- Wet Pack (49)

Food Weight	$7.50 \text{ oz.} \times 49 = 362.6 \text{ oz.} = 22.66 \text{ lb.}$
Pkg. Weight	$\underline{.50 \text{ oz.} \times 49 = 24.5 \text{ oz.} = 1.53 \text{ lb.}}$
Total	24.19 lb.

- Refrigerated (48)

Food Weight	$7.40 \text{ oz.} \times 48 = 355.2 \text{ oz.} = 22.20 \text{ lb.}$
Pkg. Weight	$\underline{.50 \text{ oz.} \times 48 = 24.0 \text{ oz.} = 1.50 \text{ lb.}}$
Total	23.70 lb.

- Frozen (48)

Food Weight	$7.40 \text{ oz.} \times 48 = 355.2 \text{ oz.} = 22.20 \text{ lb.}$
Pkg. Weight	$\underline{.50 \text{ oz.} \times 48 = 24.0 \text{ oz.} = 1.50 \text{ lb.}}$
Total	23.70 lb.

3.5.1 Cont'd

- Total Food and Primary Pkg. Wt/Mission

	Food lb.	Pkg. lb.	
Bev.	26.90	21.88	48.78
RTE	17.28	2.74	20.02
Rhyd	21.22	5.46	26.68
Wet Pack	22.66	1.53	24.19
Refrig.	22.20	1.50	23.70
Frozen	<u>22.20</u>	<u>1.50</u>	<u>23.70</u>
	132.46	34.61	167.07
Food	132.46		
Pkg.	<u>34.61</u>		
Total	167.07		

Arrangement

- BEV/RTE Figure 3.5.1-1 Same as System IV
- Rehydratable/Wet Pack Fig. 3.5.1-2

The crew day supply of 25 rehydratables and 7 wet packs is overwrapped. Seven overwraps, comprizing the mission requirement are brought aboard in a logistics liner and are arranged in a cabinet for use on a one per day basis.

- Refrigerated Food Figure 3.5.1-3 Same as System IV
- Frozen Food Figure 3.5.1-3

The mission requirement of 48 frozen food items is overwrapped. One overwrap is packaged in a logistics liner to be kept frozen at all times.

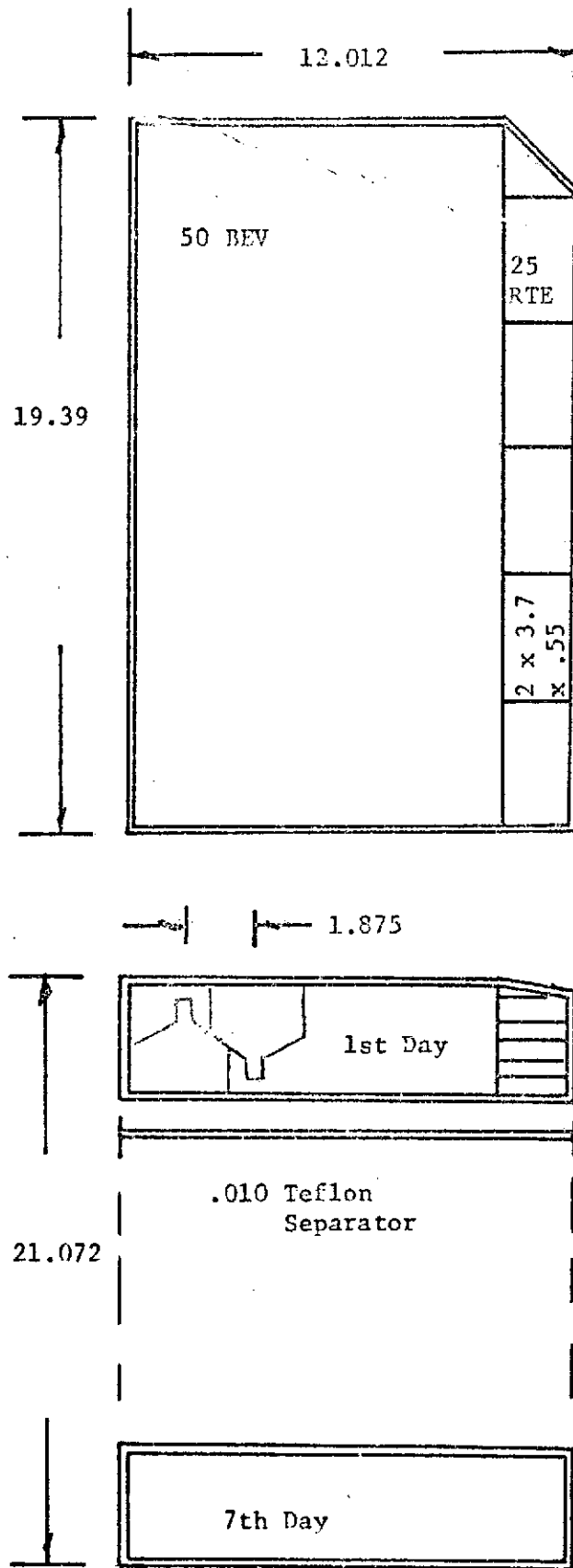


FIGURE 16 BEV/RTE ARRANGEMENT

3.5.1 Cont'd

Rehydratable/Wet Pack Arrangement

Reqd. Rehyd 168 175 = 224 = 7 x 32 = 7 x 8 x 4

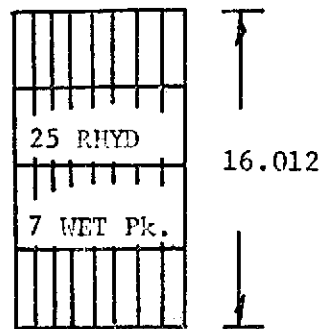
Wet Pack 42 49

210 = 7 x 30 = 7 x 6 x 5

Pkg. Dimension 4 x 4 x 1.03 4 x 4 x 1.03

Stack " 7 x 4 x 8 7 x 8 x 4

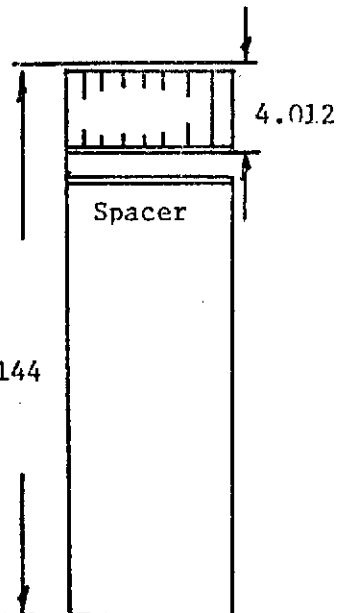
8.252 28 16 8.24 28 32 4.12



25 + 7 = 32 pkg/day

175 Rhyd

32 $\frac{\text{pkg}}{\text{day}}$ x 7 day = 224 = $\frac{49 \text{ Wet Pk}}{224}$



8.24
 $\frac{.012}{8.252}$

4.012
 $\frac{7}{28.084}$
 $\frac{.060}{28.144}$

H = 4.012 x 7 + .060 = 28.144

FIGURE 17

REHYDRATABLE WET PACK ARRANGEMENT

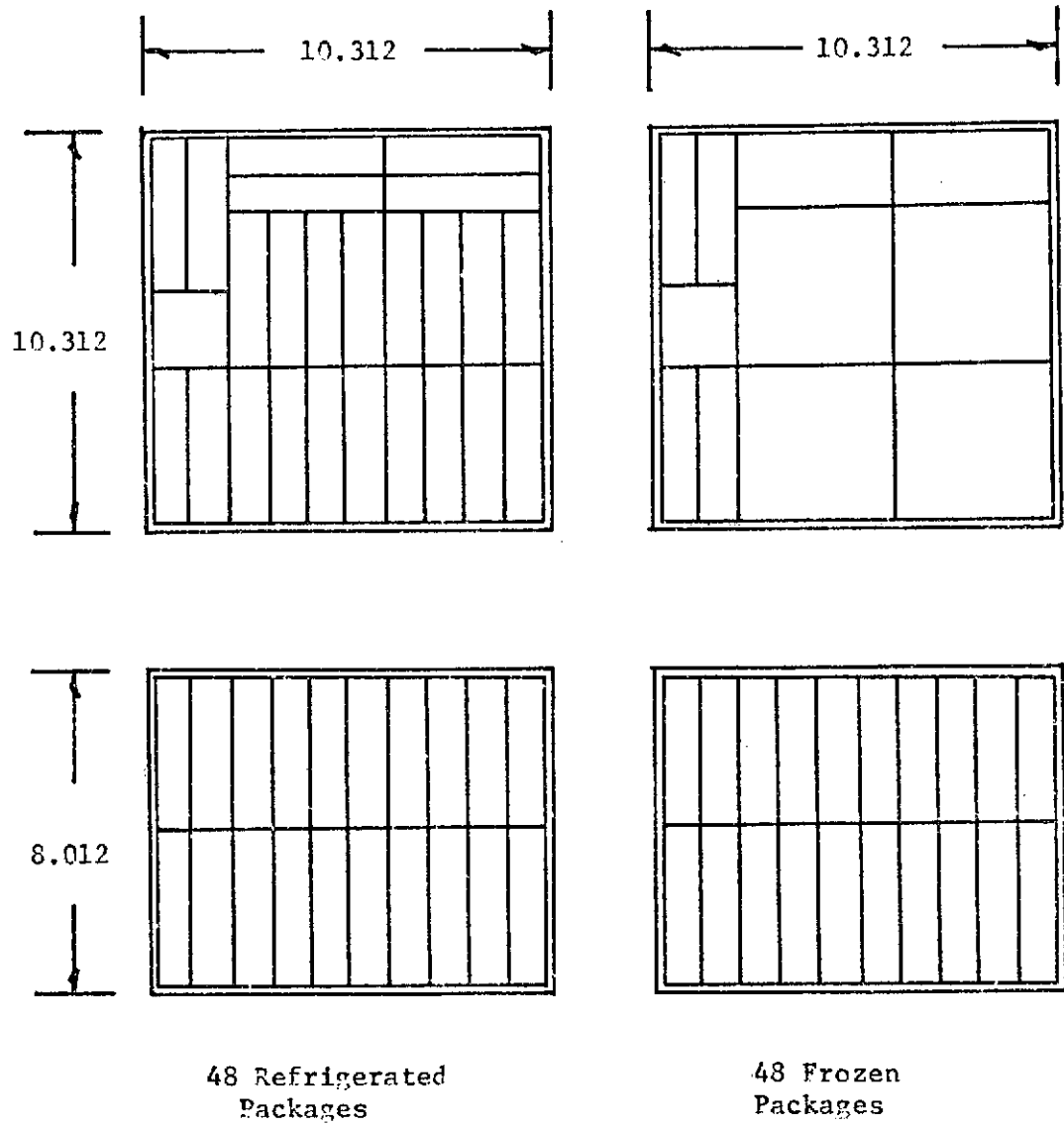


FIGURE 18
REFRIGERATED AND FROZEN FOOD PKG. ARRANGEMENTS

3.5.1 Cont'd

Dimensional Analysis

Bev/RTE	W	D	H	In ³	Ft ³
a ₁ 50 Bev/25RTE	12.000	19.378	2.989		
Overwrap .006/S	<u>.102</u>	<u>.102</u>	<u>.012</u>		
b ₁ One Day Layer	12.012	19.390	3.001	720	.41
Rhyd/Wet Pack					
a ₂ 25Rhyd/7 Wet Pk.	8.240	16.000	4.000		
Overwrap .006/S	<u>.012</u>	<u>.012</u>	<u>.012</u>		
b ₂ One Day Layer	8.252	16.012	4.012	530	.31
Refrigerated					
a ₃ 48 Ref. Pkg.	10.300	10.300	8.000		
Overwrap .006/S	<u>.012</u>	<u>.012</u>	<u>.012</u>		
b ₃ Mission Supply	10.312	10.312	8.012		
Frozen					
a ₄ 48 Frozen Pkg.	10.300	10.300	8.000		
Overwrap .006/S	<u>.012</u>	<u>.012</u>	<u>.012</u>		
b ₄ Mission Supply	10.312	10.312	8.012		

3.5.2 Stowage Equipment

<u>BEV/RTE Liner</u>	W	D	H	In ³	Ft ³
a ₁ Food-Day Layer	12.00	19.378	2.989	695.	.40
b ₁ Overwrapped Layer	12.012	19.390	3.001	699	.40
c ₁ Spacers.010 ea.	12.012	19.390	.060	14.	
d ₁ 7 Layer Stack	12.012	19.390	21.067	4907	2.84
e ₁ Clearance .062/S	.124	.124	.124		
f ₁ Inside Dimension	12.136	19.514	21.191	5018.	
g ₁ Liner Th. .060/S	.120	.120	.120		
h ₁ Outside Dimension	12.256	19.634	21.311	5128	2.97

3.5.2 Cont'd

Rehydratable/Wet Pack Liner

	W	E	H	in ³	Ft ³
a ₂ Food-Day Layer	8.240	16.000	4.000	527	.307
b ₂ Overwrapped Layer	8.252	16.012	4.012	530.	
c ₂ Spacers .010 ea.	8.252	16.012	.060	7.92	
d ₂ 7 Layer Stack	8.252	16.012	28.144	3718.	2.15
e ₂ Clearance .062/S	.124	.124	.124		
f ₂ Inside Dimensions	8.376	16.136	28.268	3820	
g ₂ Liner Thick. .060/S	.120	.120	.120		
h ₂ Outside Dimension	8.496	16.256	28.388	3920	2.27

Cabinet-See Sep. Analysis End Sec. V

Refrigerated Food Liner

a ₃ Food-Mission Quant.	10.300	10.300	8.000	849	.491
b ₃ Overwrapped Layer	10.312	10.312	8.012	852	.493
e ₃ Clearance .062/S	.124	.124	.124		
f ₃ Inside Dimensions	10.436	10.436	8.136	886	
g ₃ Liner Th. .060/S	.120	.120	.120		
h ₃ Outside Dimensions	10.556	10.556	8.256	920	.532

Frozen Food Liner

a ₄ Food Mission Quant.	10.300	10.300	8.000	849	.491
b ₄ Overwrapped Layer	10.312	10.312	8.012	852	.493
e ₄ Clearance .062/S	.124	.124	.124		
f ₄ Inside Dimension	10.436	10.436	8.136	886	
g ₄ Liner Th. .060/S	.120	.120	.120		
h ₄ Outside Dimension	10.556	10.556	8.256	920	.532

Material Densities

- Liners-Epoxy moulding compound-glass fiberfill .068 lb/in³
- Spacers-TFE .078 lb/in³
- Overwraps-polyeth .035 lb/in³

3.5.2 Cont'd

Material Weights

• Overwraps	$\rho = .035 \text{ lb/in}^3$	$\text{In}^3 \times n \times \rho = \text{lb.}$
BEV/RTE	$(b_1 - a_1) \text{ in}^3$ (699-695)	4 7 x .035 = .980
Rhyd/Wt Pk.	$(b_2 - a_2) \text{ in}^3$ (530-527)	3 7 x .035 = .735
Refrig	$(b_3 - a_3) \text{ in}^3$ (852-849)	3 1 x .035 = .105
Frozen	$(b_4 - a_4) \text{ in}^3$ (852-849)	3 1 x .035 = .105
• TFE Spacers	$\rho = .078 \text{ lb/in}^3$	$\text{In}^3 \times n \times \rho = \text{lb.}$
BEV/RTE	c_1	14 6/6 x .078 = 1.09
Rhyd/Wt Pk.	c_2	8 6/6 x .078 = .624
Refrig	None	
Frozen	None	
• Liners	$\rho = .068 \text{ lb/in}^3$	
BEV/RTE	$(h_1 - f_1) \text{ in}^3$ (5128-5013)=110	1 x .068 = 7.48
Rhyd/Wt Pk.	$(h_2 - f_2) \text{ in}^3$ (3920-3820)=100	1 x .068 = 6.80
Refrig.	$(h_3 - f_3) \text{ in}^3$ (920-886) = 34	1 x .068 = 2.31
Frozen	$(h_4 - f_4) \text{ in}^3$ (920-886) = 34	1 x .068 = 2.31

Liner Weights Including Overwrap and Spacer Weights

Liner	BEV/RTE	Vol.	Rhyd/Wet Pk.	Vol.	Ref.	Vol.	Frozen	Vol.
Overwrap	7.48		6.80		2.31		2.31	
Spacer	.980		.734		.105		.105	
	<u>1.09</u>		<u>.624</u>		<u>None</u>		<u>None</u>	
	9.550		8.159		2.415		2.415	
	<u>1b.</u>	Vol.		<u>Food Overwrap</u>	Vol.			
BEV	9.550	2.97		2.84				
Rhyd Wt. Pk.	8.159	2.27		2.15				
Refrig.	2.415	.532		.493				
Frozen	<u>2.415</u>	<u>.532</u>		<u>.493</u>				
	22.539	6.304	Ft ³	5.976	Ft ³			

3.5.2 Cont'd

Food Volume

BEV/RTE	2.84 Ft ³
Rhyd/Wt Pk.	2.15 Ft ³
Refrig.	.50
Frozen	<u>.50</u>
	5.99 Ft ³

Summary Rationale

<u>Food and Primary Packaging</u>		lb.	Ft ³
Weight		167.1	
Volume Bev/RTE	2.84 Ft ³		5.99
Rhyd/Wet Pack	2.15 Ft ³		
Refrig.	.50 Ft ³		
Frozen	.50 Ft ³		

Equipment

Case 1 Logistics Liners (No Meal Choice System)

		lb.	Ft ³
BEV/RTE Liner	7.48 lb.		
Overwraps	.98 lb.		
Spacers	<u>1.09 lb.</u>	9.550	2.97
Rhyd/Wet Pack	6.80 lb.		
Overwraps	.74		
Spacers	<u>.62</u>	8.16	2.27
Refrig Food	2.31 lb.		
Overwrap	<u>.105 lb.</u>	2.42	(.532)*
Frozen Food	2.31 lb.		
	<u>.105 lb.</u>	<u>2.42</u>	<u>(.532)*</u>

*Charged to refrigerator and freezer

Case 1 - Liner Summary

22.55 lb. 5.24 Ft³

3.5.2 Cont'd

Case 2 + 1 Meal Choice Cabinet

With BEV/RTE Drawer

and Rhyd/Wt. Pack Drawer 43.5 lb.

Refrigerator Liner 2.42

Freezer Liner 2.42

48.3 lb. 9.8 Ft³

+Equivalent to 1 Meal choice analysis as per Vol. II

Appendix D - Package and Stowage Analysis

Case 3 ~~#~~Full Meal Choice Cabinet
with separate drawers
with separate drawers

lb. Ft³

for Bev, RTE, Rhyd/WetPack 78.5

plus Refrig. liner and 2.41

freezer liner 2.41

83.3 lb. 10.8 Ft³

~~#~~Equivalent to full meal choice analysis as per Vol II

Appendix D - Package and Stowage Analysis

Hot and Cold Water System

(Same as System III and IV) 14.8 lb. .60 Ft³

Wipes and Dispensers

(Same as System III and IV)

Large Wipes 3.15 lb.

Small Wipes 2.18 lb.

5.33 lb.

Large Dispenser 1.1 lb.

Small Dispenser 1.1 lb.

2.2 lb. .23 Ft³

3.5.2 Cont'd

Utensils Add Hot/Cold Handling Utensil

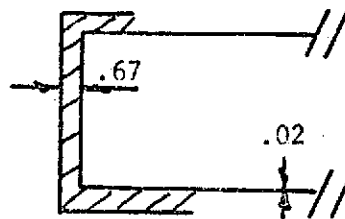
	1b.
Fork (6)	.42
Spoon (6)	.30
Scissor (6)	.63
Handle (1)	<u>.10</u>

1.45 lb.	1.45 lb.	.14 Ft ³
----------	----------	---------------------

Trays as per System III and IV	9.0 lb.	.925 Ft ³
--------------------------------	---------	----------------------

Hot Air Convection Oven - sized to accept two layers of
three hot inserts 5.2 x 12.9 x 1.2. Requires cavity of
15 x 17 x 4.56

Oven



Inside .020/Side=.04
Insulation .67/Side=1.34
Skin .020/Side=.04

Dimensional Volume

	W	D	H	
	15	17	4.56	= 1160 in ³ .67 Ft ³
Inside Skin	.04	.04	.04	
Insulation	1.34	1.34	1.34	
Outside Skin	<u>.04</u>	<u>.04</u>	<u>.04</u>	
	16.420	18.420	5.980	= 1785 in ³ 1.03 Ft ³
Plenum Chamber Vo.	2	x	4.56 x 17	= 154 in ³
Blower Motor	8	x	8 x 8	= 512 in ³
External Ducting	1	x	4.56 x 17	= <u>77 in³</u>
				743 in ³ = <u>.43Ft³</u>
Oven Dimensional Vol.				1.46 Ft

3.5.2 Cont'd

Weight - Including Penalties

Box and insulation	14.32 lb.	Ref. Appendix D
Blower + Motor + Ducting	6.00 lb.	Estimate
Heat Loss Penalty	5.6 lb.	Ref. Appendix D
Energy Penalty	<u>15.4 lb.</u>	Ref. Appendix D
	41.32 lb.	

Refrigerator 14 x 10 x 9 Cavity as per System III

27.2 lb. 1.32 Ft³

Freezer

Estimate for freezer penalties based upon surface area ratio of required cavity to larger cavity calculation.

Required Cavity Surface Area
= .64

Analyzed Cavity Surface Area

Required Cavity 14 x 10 x 9

Surface Area
 $2 (10 \times 9) = 180 \text{ in}^2$
 $2 (14 \times 10) = 252 \text{ in}^2$
 $2 (14 \times 9) = \underline{280 \text{ in}^2}$
 712 in²

Analyzed Cavity 15 x 13 x 13

$2 (13 \times 13) = 338 \text{ in}^2$
 $2 (15 \times 13) = 390 \text{ in}^2$
 $2 (15 \times 13) = \underline{390 \text{ in}^2}$
 1118 in

Surface Area Ratio $\frac{712}{1118} = .64$

3.5.2 Cont'd

<u>Freezer Weight</u>	0° Freezer	Analzyed	x.64 = Required
Box		29 lb.	.64 18.6 lb.
Elect. Penalty		6.7	.64 4.3 lb.
Heat Rej. Penalty		11.9	.64 <u>7.7 lb.</u>
			30.6 lb.

Trash Compactor

Piston Cylinder - Hand Operated Mechanism

Cylinder Bore 6 in D x 18 in L = 505 in³ = .29 Ft³

Estimated Weight Total 15 lb.

3.5.3 Installation

Food Lockers

BEV/RTE Liner	12.256	x 19.634	x 21.311	Ft ³ 2.97
Structure-Clearance	<u>2.1</u>	<u>3.1</u>	<u>2.1</u>	
and Access	14.356	22.734	23.4111	4.42
Rhyd/Wet Pack	8.496	16.256	28.387	
Penalties	<u>2.1</u>	<u>3.1</u>	<u>2.1</u>	
	10.596	19.356	30.487	3.58

Refrigerator and freezer liners included in the equipment installation

Q Volumes

BEV/RTE $\Delta V = 1.45 \text{ Ft}^3$

Rhyd $\Delta V = \frac{1.31 \text{ Ft}^3}{2.76 \text{ Ft}^3}$

Weight

BEV/RTE Locker	1.45 Ft ³ x 3.6 lb/ft ³	= 5.2 lb.
Rhyd Locker	<u>1.31 Ft³</u> x 3.6 lb/ft ³	= <u>4.7 lb.</u>
	2.76 Ft ³	9.9 lb.

Equipment Installation

$$\text{Oven} \quad 16.4 \times 18.4 \times 5.9 = 1.46$$
$$18.5 \times 21.5 \times 8.0 = 1.87$$

$$\text{Elower} \quad 8 \quad \times \quad 8 \quad \times \quad 8 \quad = \quad .297$$

$$10.1 \times 11.1 \times 10.1 = .637$$

Total Oven Installation $\Delta_1 + \Delta_2 = .75 \text{ Ft}^3 \times 3.6 = 2.70 \text{ lb.}$

$$\text{Penalty Vol.} \times 3.6 \text{ lb/ft}^3 = \text{lb.}$$

Wipes Dispensers (Ref. Syst. III)	.08 Ft ³	.29 lb
-----------------------------------	---------------------	--------

Refrigerator (Ref. Syst. IV)	.75 Ft ³	2.70 lb
------------------------------	---------------------	---------

Freezer (Same as Refrig.)	.75 Ft ³	2.70 lb
---------------------------	---------------------	---------

Compactor

$$\text{Dim} \quad 6 \text{ in D} \times 18 \text{ in L} = .29 \text{ Ft}^3$$

Penalty 1 in D 18 in L*

Installed 7 in D 36 in = .78 Ft³

$$\Delta V = .49 \text{ Ft}^3 \quad .49 \text{ Ft}^3 \quad 1.76 \text{ lb}$$

*Length of Actuation Sub Total from above	<u>1.15</u>	<u>4.14</u>
---	-------------	-------------

Total Equipment Installation	3.22 Ft ³	11.59 lb.
------------------------------	----------------------	-----------

Utensil Stowage	.07 Ft ³	.30 lb
-----------------	---------------------	--------

Trays (As per System III)	.95 Ft ³	3.42 lb
---------------------------	---------------------	---------

3.5.3 Cont'd

Trash Stowage

	Stowed Vol. Ft ³	Compaction Ratio	Trash Vol.	
Bev.	2.36	1.5/1	3.54	
RTE	.48	.25/1	.12	
Rhyd/Wet Pk	2.17	1/1	2.17	
Refrig.	.49	1/1	.49	
Frozen	.49	1/1	<u>.49</u>	
			6.81	
			6.81 Ft ³	24.52 lb.
Work Surface (As per system III)			.595Ft ³	2.15 lb.
Miscellaneous Hardware			.13 Ft ³	.45 lb.